AGRICULTURAL ENGINEERING

JULY • 1953

In this Issue . . .

New Frontiers for Agricultural Engineers in Food Production

Results of Engineering Studies of Grain Cooling by Air

Corn Shelling Efficiency with a Grain Combine Cylinder

Recent Trends in the Application of Fasteners for Farm Equipment

Recommendations for the Design and Construction of Tile Drains

THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Pivotal Action

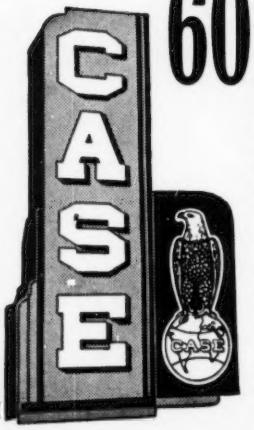
Cuts Full Slice on Curves

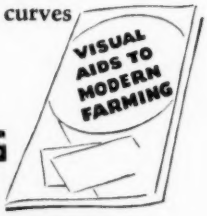
This revolutionary plow now makes contour plowing practical and is ideal for terrace building. The front bottom cuts neither too narrow nor too wide. Scientifically-located pivot point keeps all bottoms of Case Breakaway-Contour Plows cutting true-width furrows on contour curves. Takes but a minute to hook up to Eagle Hitch of Case Tractor, right from the seat and depth can be adjusted from seat. Constant Hydraulic Control lifts, effortlessly. Pivotal Action eliminates side draft, works as beautifully on curves as on straightaway.

Breaks away, too! Stumps and stones that would damage fixed plows simply cause the Case Mounted Breakaway-Contour Plow to uncouple from its foreframe. Driver recouples in a jiffy just by backing tractor. He lifts plow over obstruction with Constant Hydraulic Control and goes on plowing—little time lost!

Case Pivotal Action Plows are conservation plows. Not only aiding conservation of soil and water, they help save human energy and time, promoting ever-greater production per man, per hour, per acre, and per machine.

For decades Case has spearheaded the war against waste by providing farmers with implements ideally suited to conservation practices. Now, with its remarkable Eagle Hitch and implements far advanced in concept and function, Case continues to create weapons for the fight.





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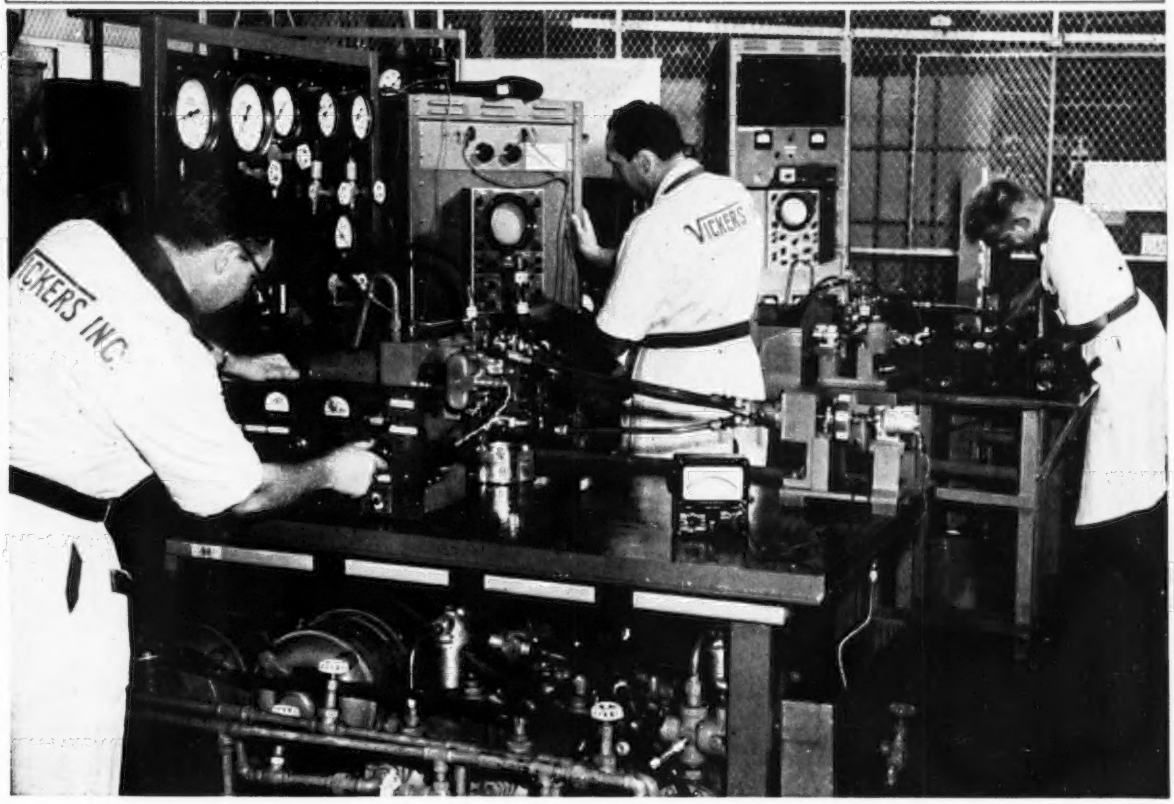
by Specifying VICKERS Hydraulics



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AGRICULTURAL ENGINEERING

Established 1920

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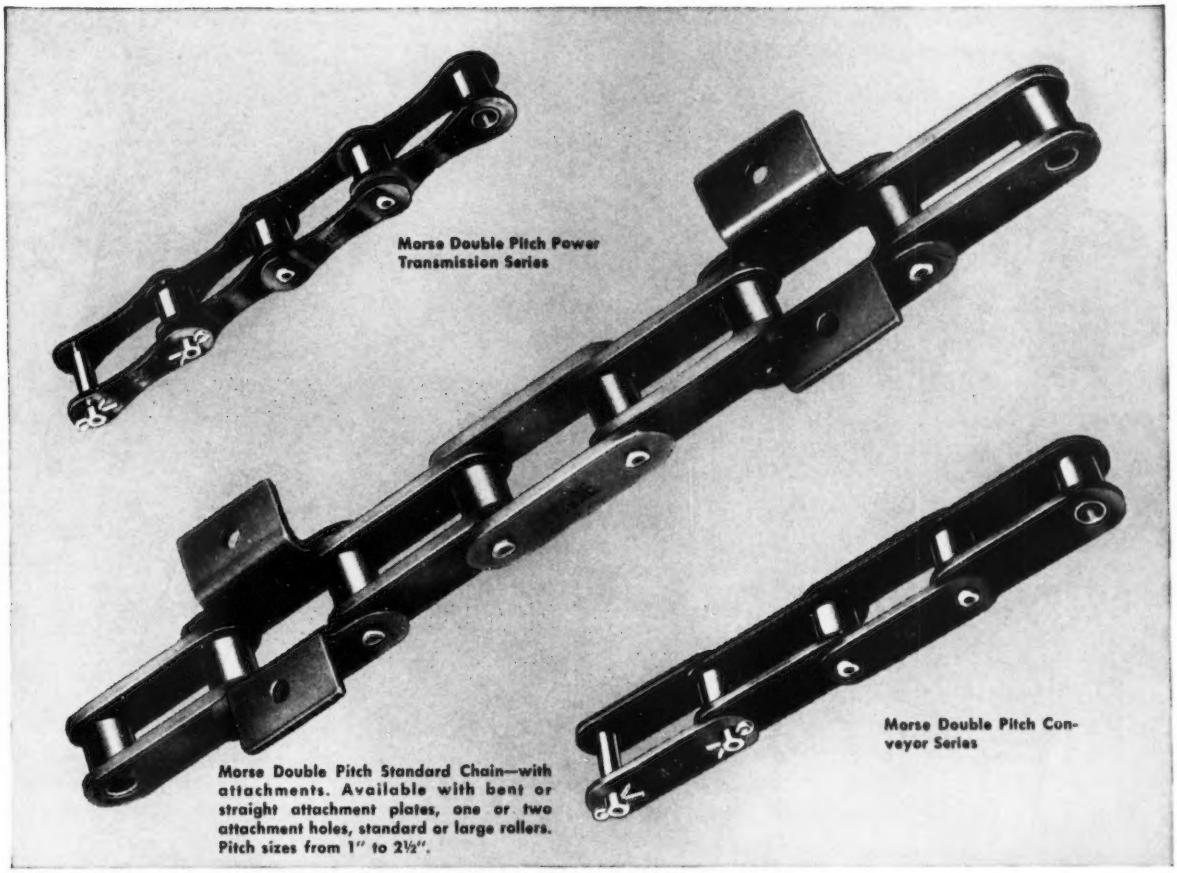
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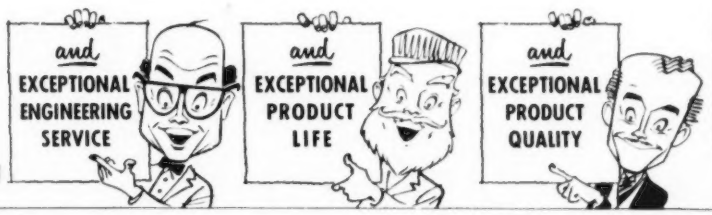

MORSE
MECHANICAL *POWER TRANSMISSION* PRODUCTS

Fafnir Wide Inner Ring Bearing, with Self-Locking Collar and Mechani-Seals. Other types include Flangettes, Pillow Blocks, Standard Radial, Wirelac and Thrust Bearings.

International Harvester's new Model 20-C Field Harvester provides low-cost, flexible harvesting for forage or row crops.

Blueprint...

for more seasons of efficient harvesting

From the day it was conceived on International Harvester's drawing boards, the new dual-purpose McCormick Field Harvester was designed for speed, high capacity, flexibility and economical performance. Fafnir Ball Bearings fit this blueprint for efficient harvesting perfectly. Fafnir Bearings are used on key rotating elements including the rotor shaft, conveyor drive shaft, apron drive sprocket shaft and gear case coupler shaft . . . elements where long life, low overall cost and minimum friction are essential.

Like the other leading farm machinery manufacturers, International Harvester finds ball bearings in the Fafnir Line that meet design requirements exactly. And Fafnir offers farm machinery manufacturers more than high quality and wide variety. It brings to every application the Fafnir "attitude and aptitude" . . . a way of looking at bearing problems from the designer's angle . . . an aptitude for providing the *right* bearing for every job. Maybe these Fafnir attributes can help you. The Fafnir Bearing Company, New Britain, Connecticut.

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continues to offer

SAFETY for SURE

in the Drive Line Assembly with INTEGRAL SAFETY SHIELDS!

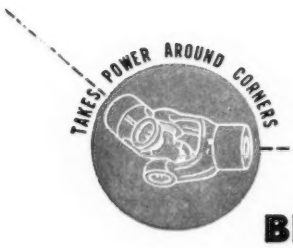
For powered farm implements, Blood Brothers Drive Line Assemblies with *Integral Safety Shields* offer definite advantages you can pass along to users. Because Safety Shields *need* not and *cannot* be removed, they reduce the possibility of farm accidents.

Exterior tube and shields are mounted on ball bearings. Thus interior power shaft tubing can revolve while shields stand still. Universal joints remain readily accessible.

An exclusive Blood Brothers feature, these Integral Safety Shields have won wide approval in the field for years. Today they are used on mowing machines, corn pickers, forage harvesters, hammer mills and other implements. You can specify them on assemblies from the K-1-C Series on through 35N Series sizes . . . on non-slip front or two-joint slip assemblies.

As an added feature for safety—*for sure*—consider what Integral Safety Shields could add to your products. Write for specific details.

For farm implements, more Blood Brothers Universal Joints are used than all other makes combined.



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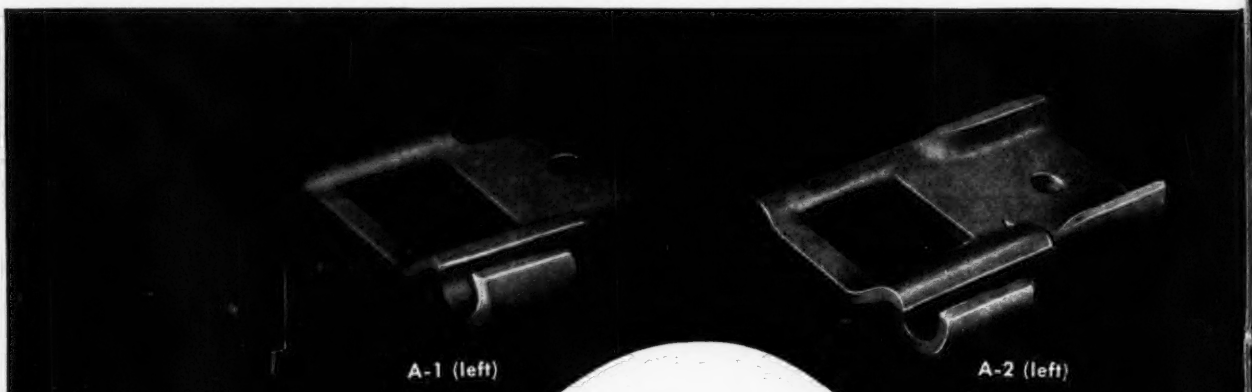

THERE'S MORE THAN MEETS YOUR EYE

You see here just 12 of the standard attachments in the complete line of Rex® Steel Detachable Chains for agricultural machinery. These are the ones most commonly used and will be "right" for many of your applications. But there are more available than "meet your eye." The complete Rex Line includes many standard attachments not illustrated here.

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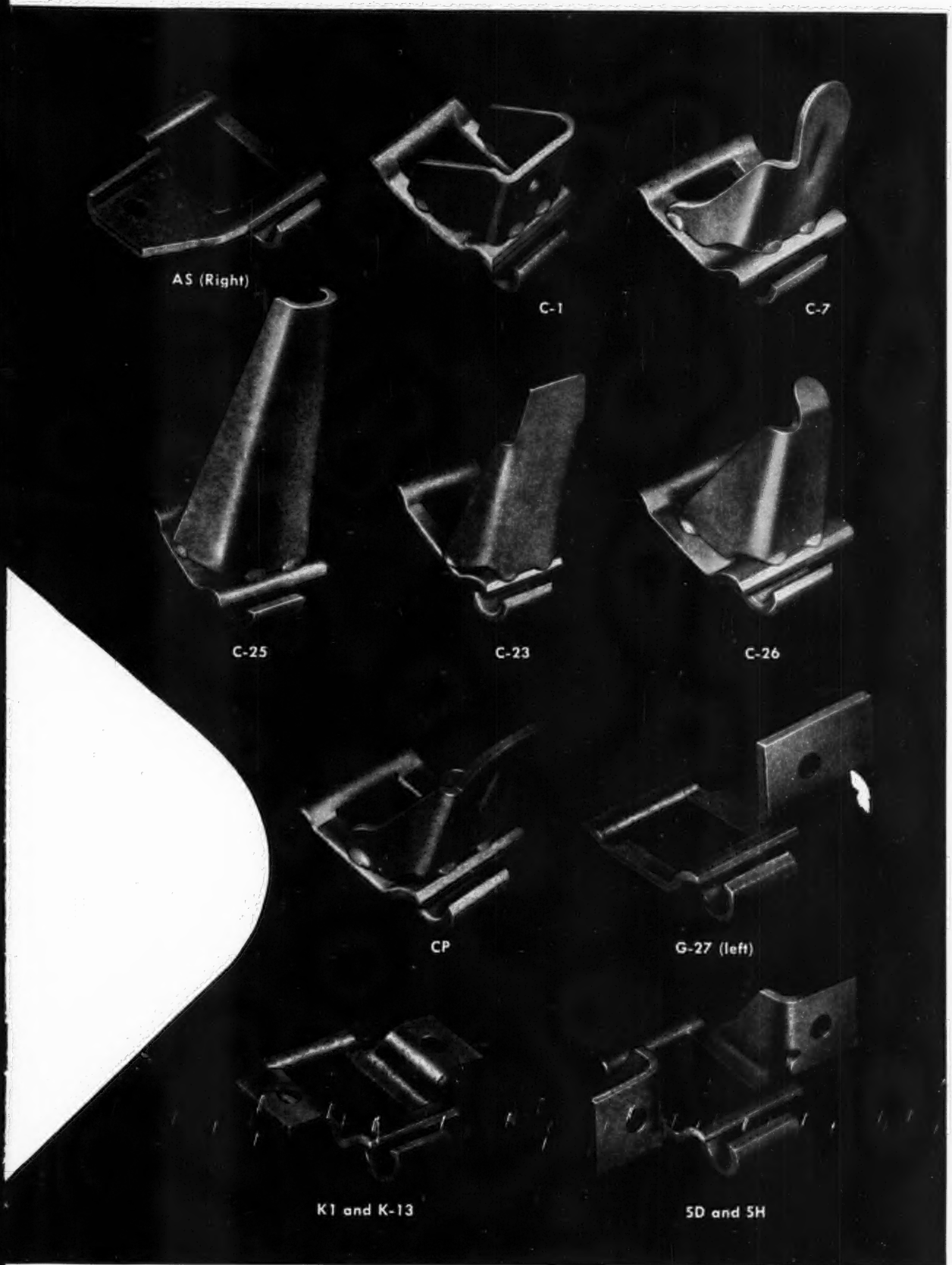

AS (Right)
C-1
C-7
C-25
C-23
C-26
CP
G-27 (left)
K1 and K-13
5D and 5H

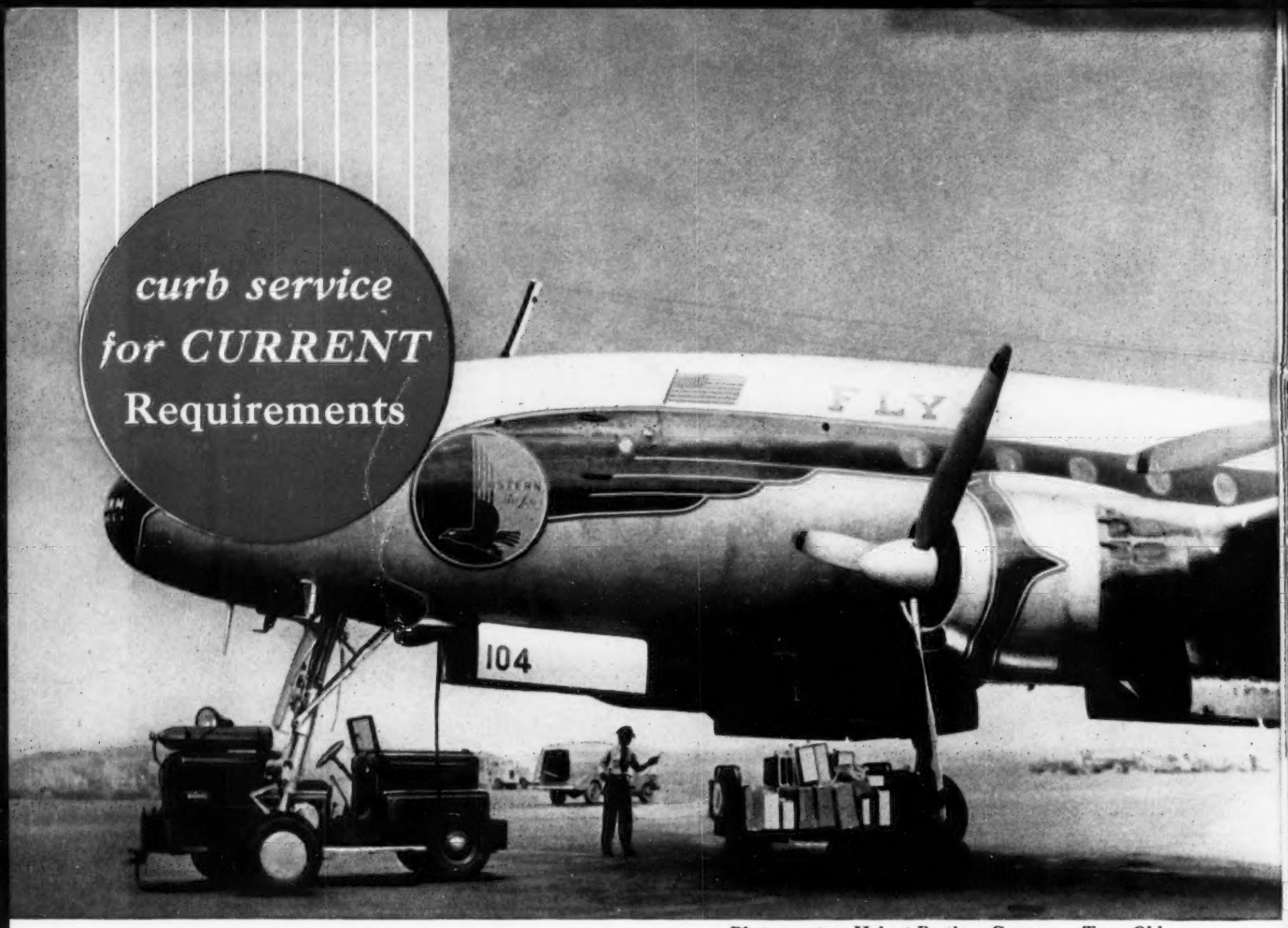
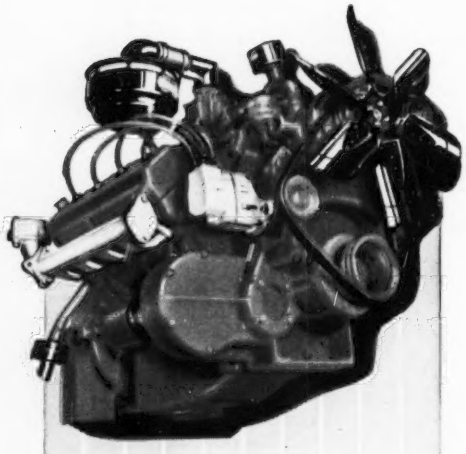


Photo courtesy Hobart Brothers Company, Troy, Ohio

Chrysler horsepower on the ground for added Safety in the Air . . .



The moment the big plane stops and the pilot cuts the engines, the generators, which in flight supply electrical power to the batteries, stop too. But the electrical equipment in the plane—air conditioning, lights, radio, food containers, everything electrical—continue operating off the plane's batteries. Only for a moment, however. In that length of time a self-propelled and self-powered energizer takes over and supplies all necessary current, even starting the plane's engines when it's time to leave.

Among the most popular mobile ground power units are the "Power-Pull" units manufactured by Hobart and powered by Chrysler. The unit pictured uses the mighty 180 horsepower Chrysler V-8 Industrial Engine and can furnish 1000 amperes, 28.5 volts of direct current under continuous operation—enough to handle the electrical load of the largest aircraft. Power from the same engine propels the unit, enabling it to serve also as a towing tractor.

This is another in the long list of important uses of Chrysler Industrial Power. Whether your equipment requires V-8 or Six cylinder engines, Chrysler can supply them with gasoline, propane or natural gas burning carburetor, 3, 4 or 5-speed transmission and other optional equipment.

For your power needs, see a Chrysler Industrial Engine Dealer, or write: ***Dept. 197, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

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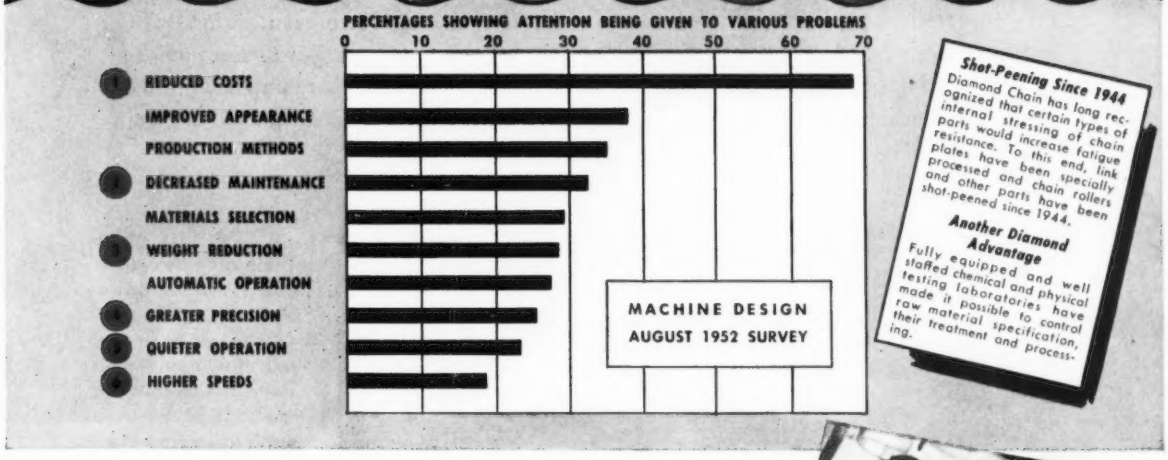
HORSEPOWER WITH A PEDIGREE

DIAMOND ROLLER CHAINS

Help to solve these Design-Engineer Problems



Shot-Peening Since 1944

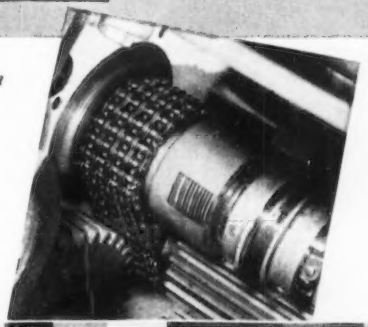
Diamond Chain has long recognized that certain types of internal stressing of chain parts would increase fatigue resistance. To this end, link plates have been specially processed and chain rollers and other parts have been shot-peened since 1944.

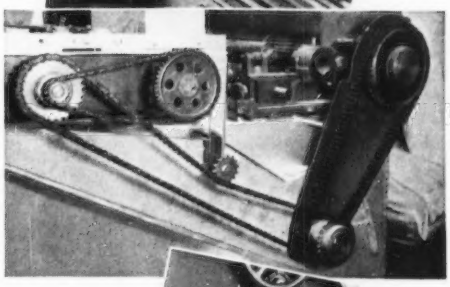
Another Diamond Advantage

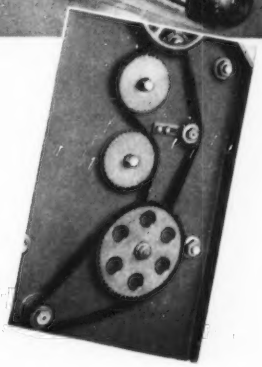
Fully equipped and well staffed chemical and physical testing laboratories have made it possible to control raw material specifications, their treatment and processing.

In the case of six of the problems designated by the *Machine Design* survey, Diamond Roller Chains provide definite help:

- **REDUCED COSTS**—Ease of installation and simplification of design reduce costs. Center distances can be short or long. And absence of separating forces reduce size and cost of bearings.
- **DECREASED MAINTENANCE**—Longer life; load is distributed over many teeth. Ease of adjustment or replacement minimizes maintenance.
- **WEIGHT REDUCTION**—Diamond Roller Chains are light compared to tensile strength and power transferred. Sprockets mesh with either side of chain eliminating heavy gear trains for multiple shaft operation.
- **GREATER PRECISION**—No slip or stretch, with definite speed ratio maintained. Diamond Chains are pre-loaded before shipment.
- **QUIETER OPERATION**—The precision manufacture of all parts, the free roll of bushings and rollers result in smooth, quiet operation at all speeds.
- **HIGHER SPEEDS**—Diamond Roller Chains are so light in relation to power transmission capacities and tensile strengths that, for all pitches and multiples, chain loading due to centrifugal force is entirely negligible at all normal ranges of chain speed, even to 4000 f.p.m.







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DIAMOND ROLLER CHAINS

there's a **JOB** to be done

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Many farmers are using rather steep lands for cultivated crops when they have idle, rich, flat lands that are best suited for intensive use if drained. By draining the wet lands, the farmer can use his steeper lands for pasture rather than erosive row crops, and can get better yields with less labor on the acres that have been drained. On many farms, land use adjustments, including drainage, are far more important than the installation of mechanical soil conservation practices.

The Austin-Western Power Grader makes short work of the construction of these shallow ditches, with their flat side slopes. When moving the windrow of earth away from the ditch, All-Wheel Steer is used to offset the rear truck so as to miss the windrow with all four wheels.

This ditch is relatively deep and narrow. The grader makes plowing cuts until there is a sizeable windrow of earth; then changes to the adjustment of wheels and blade that will best move the windrow away from the ditch. Finally, the grader will be used to spread the spoil banks.

Austin-Western
Power Graders
Road Rollers · Motor Sweepers
BALDWIN BLH LIMA-HAMILTON
Construction Equipment Division
Manufactured by
AUSTIN-WESTERN COMPANY
Subsidiary of Baldwin-Lima-Hamilton Corporation
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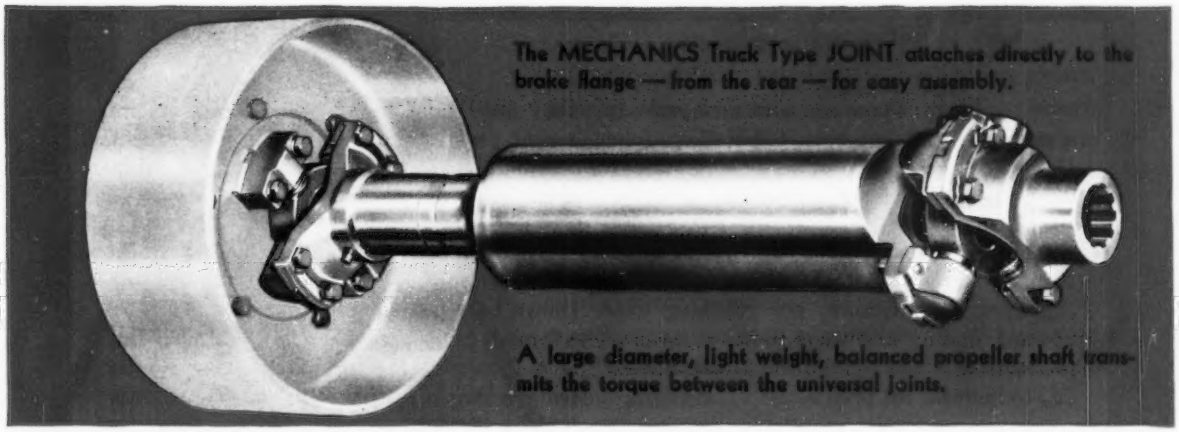
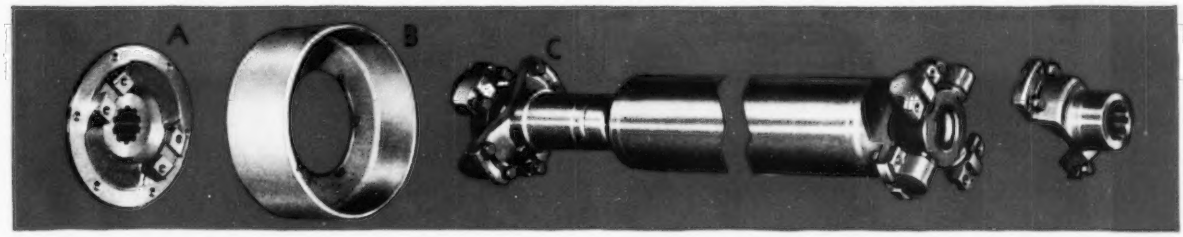
ALL Universal Joints — Are NOT Alike

MECHANICS Roller Bearing UNIVERSAL JOINTS for Trucks are specially designed with less parts and connections for *easy assembly and servicing — smooth running balance — Maximum strength* with *less weight* — and *long, trouble-free, safe operation.*


The MECHANICS Truck Type JOINT attaches directly to the brake flange — from the rear — for easy assembly.
A large diameter, light weight, balanced propeller shaft transmits the torque between the universal joints.

MECHANICS Truck Type JOINTS are assembled by attaching joint C to brake flange A independent of fastening between drum B and flange A; making possible servicing drum or joint, without disturbing other attachments or altering original brake drum or propeller shaft balance.



Let MECHANICS engineers help give *your* trucks or other heavy duty machines these competitive advantages.

MECHANICS UNIVERSAL JOINT DIVISION
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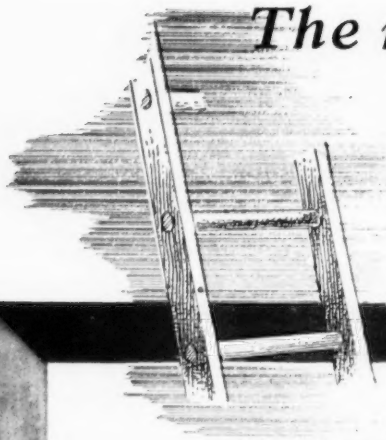
For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

The rung of a ladder....



"The rung of a ladder was never meant to rest upon, but only to hold a man's foot long enough to enable him to put the other somewhat higher."

—Thomas Huxley

Those eloquent lines embody a principle that has been followed at John Deere for more than a century of manufacturing quality farm equipment.

Pausing on each rung just long enough to make sure of their footing, John Deere engineers, for instance, are climbing ever upward, finding new ways to speed up crop production . . . to lighten the farmer's work . . . to increase his profits.

The results, of course, are manifold. But none are more valued than farmer respect and enthusiasm for John Deere products, which—in 116 years of service to American agriculture—have never been higher than they are today. And by this very measure, recent progress in the design, development, and manufacture of John Deere farm equipment has been particularly outstanding.

The latest "rung of achievement" is the introduction of the Model "70" Tractor, shown below. An important new member of a famous family, the John Deere Model "70" is a powerful tractor, with feature after feature that proclaim it the modern tractor for the large row-crop farm . . . a tractor that continues and accentuates the famed John Deere policy of offering farmers across the nation the utmost in modern design and proved performance . . . in quality farm equipment.

JOHN DEERE MOLINE, ILLINOIS

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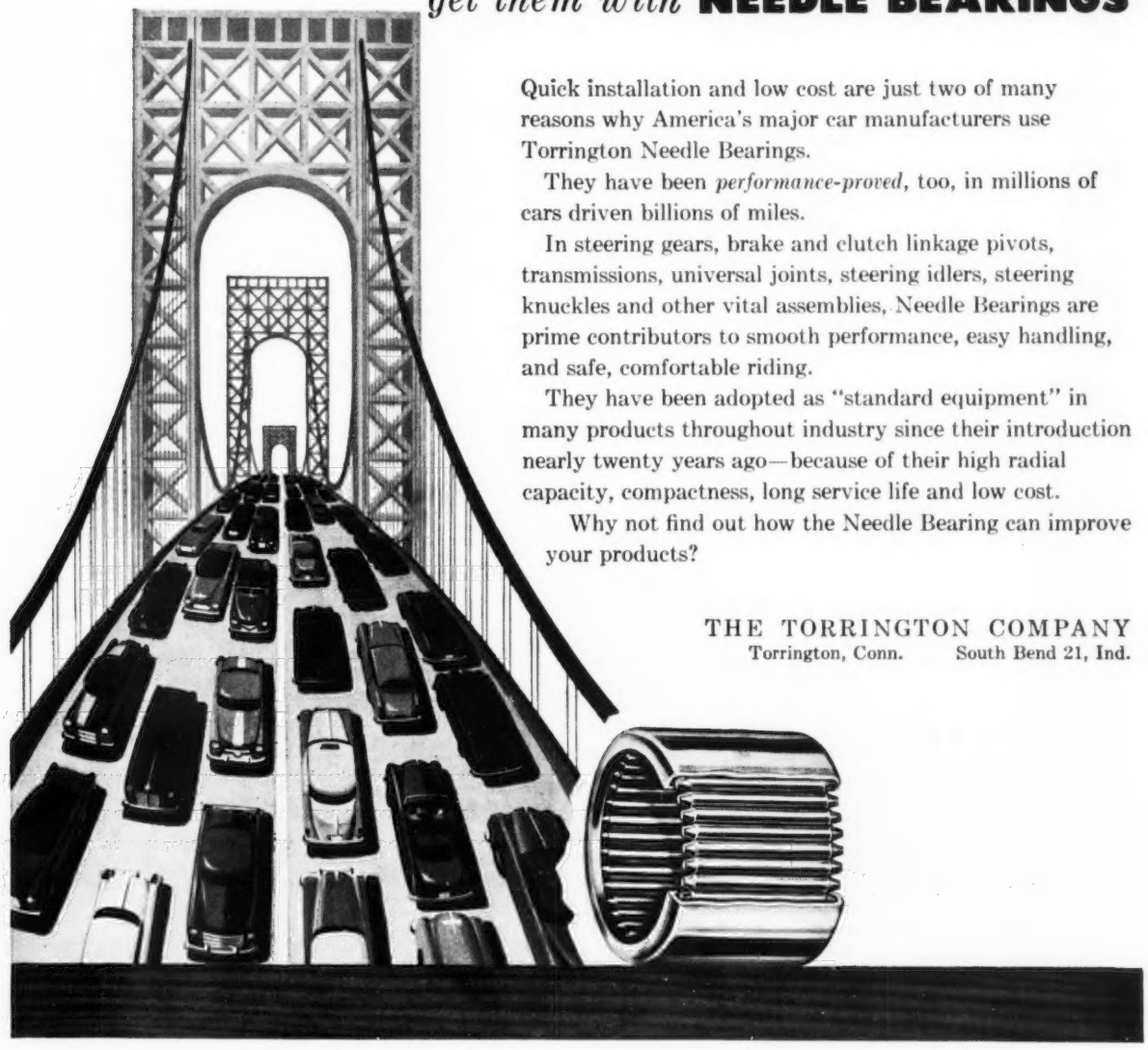
Here's how leading automobile manufacturers get them with **NEEDLE BEARINGS**



Quick installation and low cost are just two of many reasons why America's major car manufacturers use Torrington Needle Bearings.

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The scope of this joint endeavor includes both previously published and forthcoming Midwest Plans. All existing plans will be reviewed by Reynolds engineers for adaptation to aluminum — where this is practical and desirable.

On future plans, Reynolds and Midwest engineers will cooperate from the start — making the fullest use of aluminum's advantages where these apply.

This is a new advance in the cooperation of industry and Agricultural Research, in the coordination of Materials and Methods. Practical results will be forthcoming within a few months. And these new plans will be available to farmers everywhere through Midwest Plan Service and Reynolds Farm Institute.

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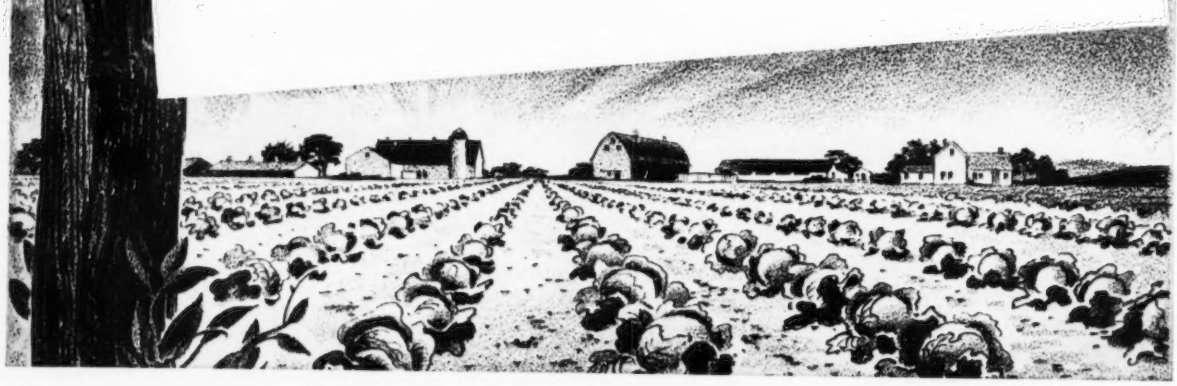

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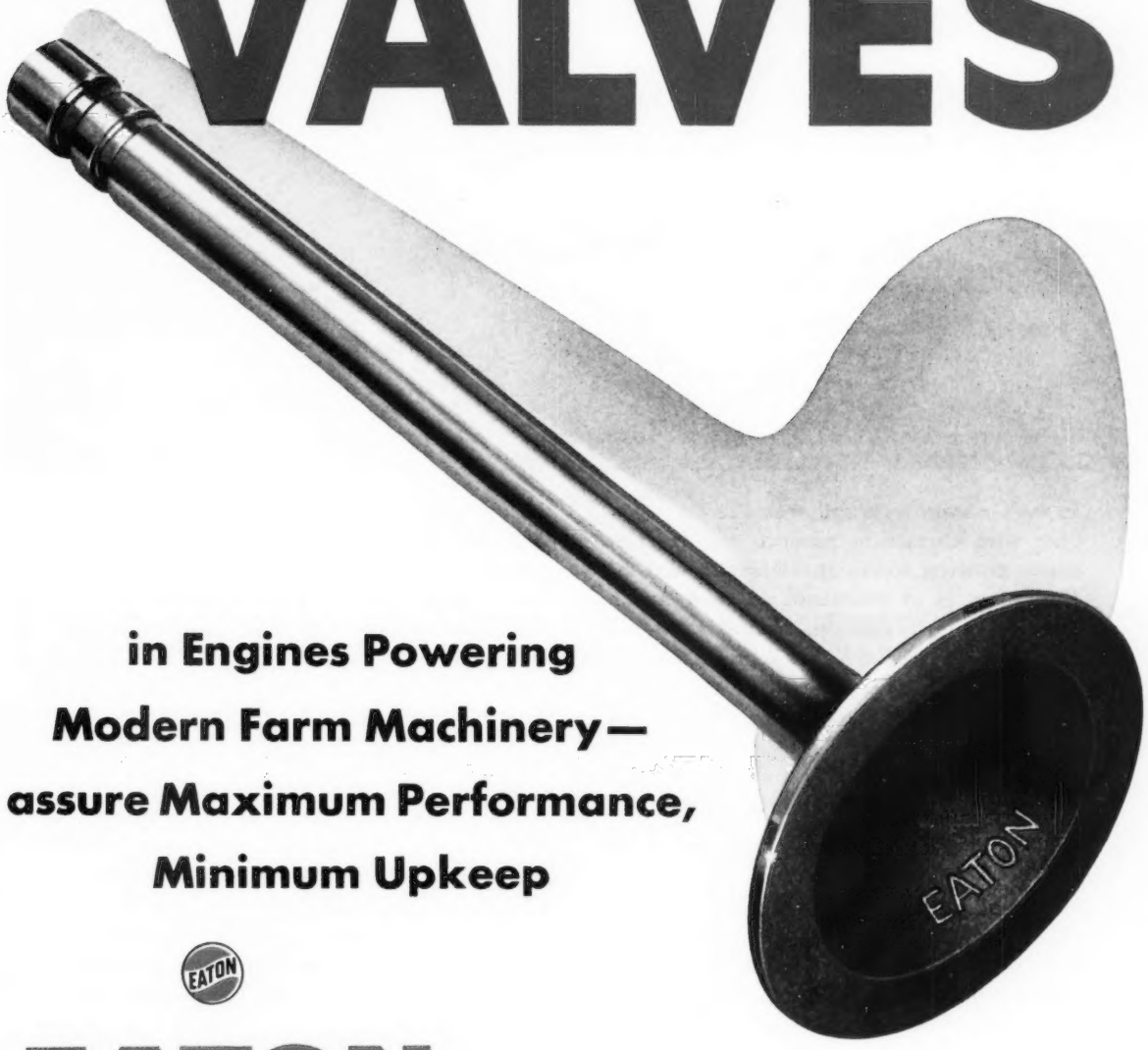

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5 MILLION ACRE GREENHOUSE!

In the far Southwest, soil, water and seed combine with climate to produce almost greenhouse growing conditions! Millions and millions of acres of wasteland are now turning green with citrus, cotton, alfalfa, vegetables. Land and climate have always been there. The main difference is that now, the crop land is level as a table, and there's water. Most of this land has been leveled and ditched by Caterpillar Diesel power. Caterpillar power draws water up, often a thousand feet, to water the crop.

Even the character of the soil is being changed. Just as you would shovel-mix a sandy soil with a black clay to produce an ideal potting soil in the greenhouse, so do these ranchers. Only *their* tools are Caterpillar Diesel Tractors and Caterpillar Earthmoving Equipment that move 10-15, even 25 yards at a time, mixing gumbo and light soil to exactly the right consistency. "Trading dirt," as this is called, is another conservation and soil improvement operation now being practiced in the Rio Grande Valley. Here, as elsewhere, you'll see predominantly Cat equipment at work. Caterpillar power has moved more dirt and cleared more land than any other man-made power in the world.

The Southwest has often been the proving ground for new methods of farming in the United States. Perhaps some day, across the width and breadth of the nation, soil will be tailor-made to the crops that will grow there. The American farmer will produce bigger yields from the same acreages. Caterpillar Diesel Tractors and Earthmoving Equipment will help him do it. Caterpillar Tractor Co., Peoria, Illinois.

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Diesel Farm Tractors

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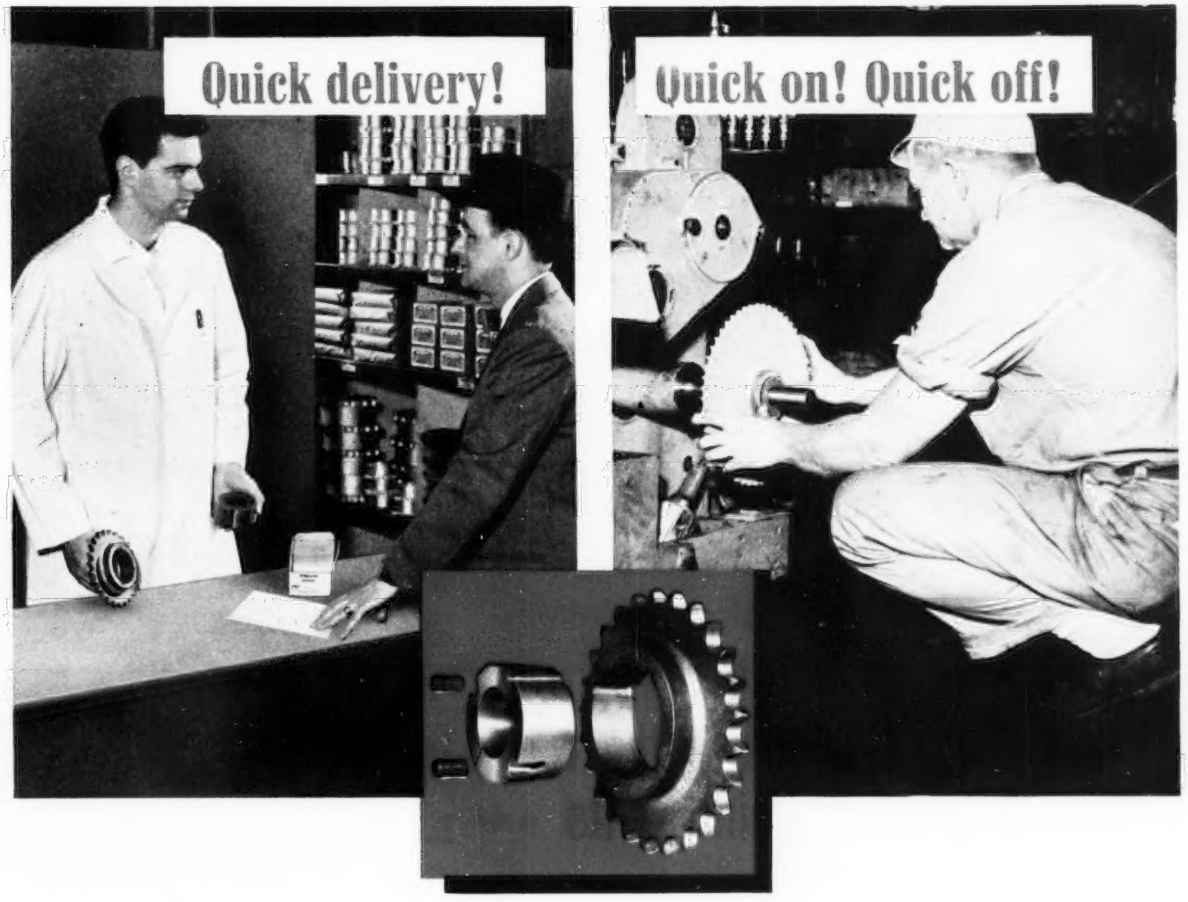
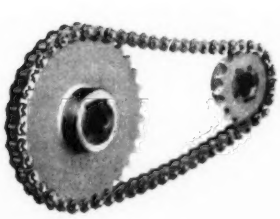


Link-Belt roller chain sprockets with taper lock bushings

HERE'S great news for users of roller chain drives! With the new Link-Belt taper lock sprocket, you don't have to fit the sprocket to the shaft. These sprockets with their taper lock bushings give you the equivalent of a shrink-fit on all standard shaft sizes.

Installation and removal are fast, simple. Set screws force and hold bushing in tapered bore of sprocket, *clamp* it tightly onto shaft. The *full length* of the bushing supports the sprocket on the shaft. Turning set screws in removal holes quickly releases it from shaft.

What's more, it's no longer necessary to wait while wheels are rebored. You can pick these sprockets right off the shelf at your nearby Link-Belt distributor or factory branch store. Available now are sizes for ½, ⅝, ¾, 1 and 1¼-in., single-width chains with other sizes to be announced. Ask for Bulletin 2449.



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ROLLER CHAIN AND SPROCKETS

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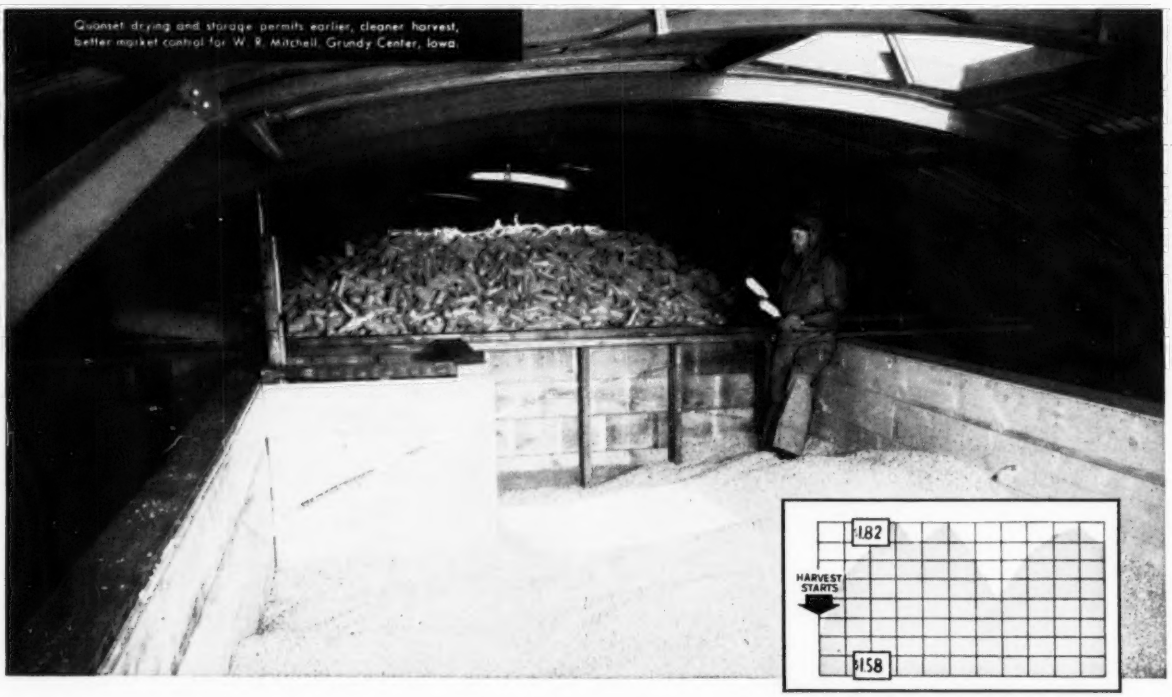

Quonset drying and storage permits earlier, cleaner harvest, better market control for W. R. Mitchell, Grundy Center, Iowa.
182
HARVEST STARTS
158

Avoid harvest time glut . . . get more for your grain with on-the-farm Quonset storage. Chart shows monthly corn prices for the 1951 crop year.

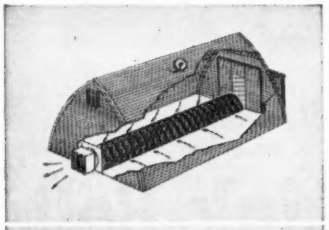
Quonset owner leads the way to greater grain profits

W. R. Mitchell, tenant farmer, of Grundy Center, Iowa, views with pride his 1952 corn crop—the first corn picked in Grundy County last year.

Because Mr. Mitchell used a Quonset combination ear corn drying unit and granary, he was able to begin picking his corn on September 27—at 30% moisture content—up to 30 days before his neighbors. Mr. Mitchell reports his picker left less corn in the field, his corn borer loss was minimized and he no longer worries about a wet fall when the corn is slow to field-dry.

This Quonset 32 x 60 dried 5,500 bushels of ear corn and its smaller bins held up to 4,000 bushels of other grains. The farm owner purchased this size because it provides ample separate bins for his own share of the crop, as well as Mr. Mitchell's.

Thousands of farmers have found that grain can be safely stored right on their own farms . . . held until market prices are right or the grain is needed for feeding. Quonsets are available for any capacity—1005 to 50,000 bushels. They are easy to finance on the Quonset Purchase Plan or through CCC Storage Facility Loans.

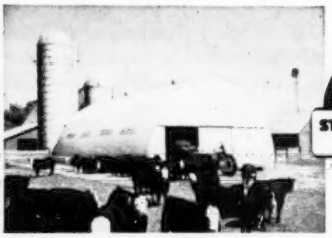


This Quonset 16 Granary, complete with fan-and-tunnel "package," lets you dry and hold your grain.

Consult your authorized Quonset dealer . . . a specialist in farm service buildings, or write us direct for complete information on the Quonset best suited to your operation.

Good-looking, durable and easy to maintain. That's the Quonset . . . all-purpose farm production tool.

"My farm machinery is easier to service," says Endren P. Johnson, Huxley, Iowa, of his Quonset.



Beef barn owned by W. A. Allely of Montezuma, Iowa, is a time-saving, labor-saving Quonset 40 x 60.

Farm for the Future . . . with Quonset®

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NATIONAL STEEL CORPORATION

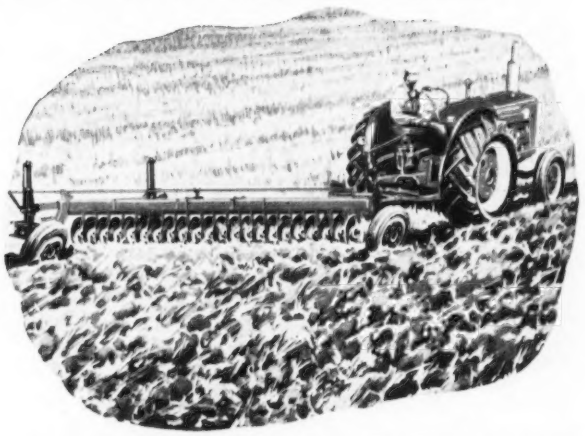
A report to you about men and machines that help maintain International Harvester leadership

STRAWS AGAINST THE WIND

IH Engineers develop new machines to help hold moisture in the soil and soil on the field

The new McCormick No. 4 stubble mulch tiller shown above offers the farmer multiple aid in his battle to retain rainfall on the land and protect the surface from erosion. It will chisel to a depth of 12 inches, breaking up plow sole and greatly increasing the water-holding capacity of the soil. Or, fitted with flat-crowned stubble sweeps, straw and weeds are sheared off cleanly three to five inches below the surface. In both cases, straw is anchored in the soil to form a protective surface. The straw cover reduces soil washing and surface compaction. In dry periods, surface of the soil is protected from destructive wind action.

The No. 4 is available with from seven to 13 spring shanks. There is unusual clearance under the frame and between teeth. For additional utility and lowered equipment investment, it also may be equipped with 2¼-inch square tool bar to which middlebuster bottoms, coil and stiff shanks, furrowers, subsoilers, ditchers and bedders can be attached. Control may be manual or hydraulic.



The new McCormick No. 22-H plow offers increased capacity and operating economy in areas where one-way plows are preferred. Design features include hydraulic control, anti-friction bearings, high overhead beam for trash clearance, and easy conversion to end-wise transport. Available in sizes to cut 12 or 15 feet.

IH engineering teamwork produced the new No. 4 stubble mulch tiller, the No. 22-H plow, and many other tillage machines for special farming conditions. On hundreds of such problems, IH research, engineering and manufacturing men spend their time and talent to achieve a common goal—that of providing farmers everywhere with equipment that suits their individual farming needs exactly.

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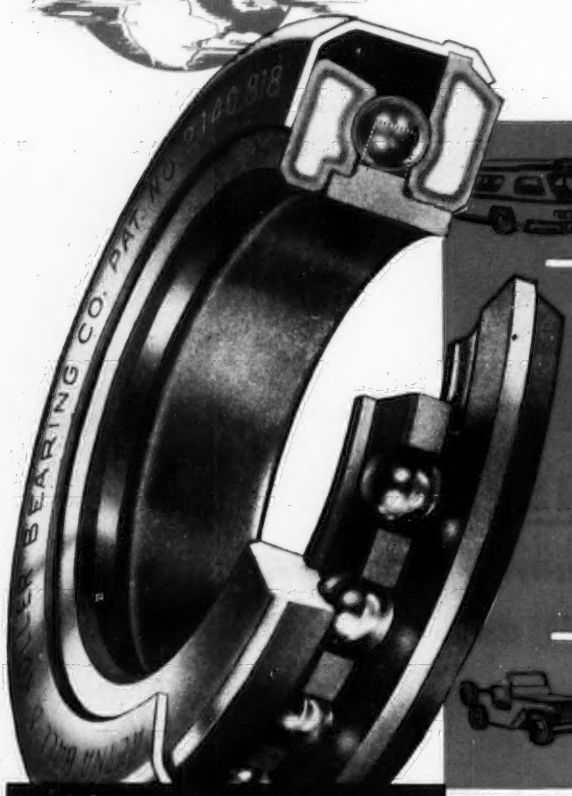

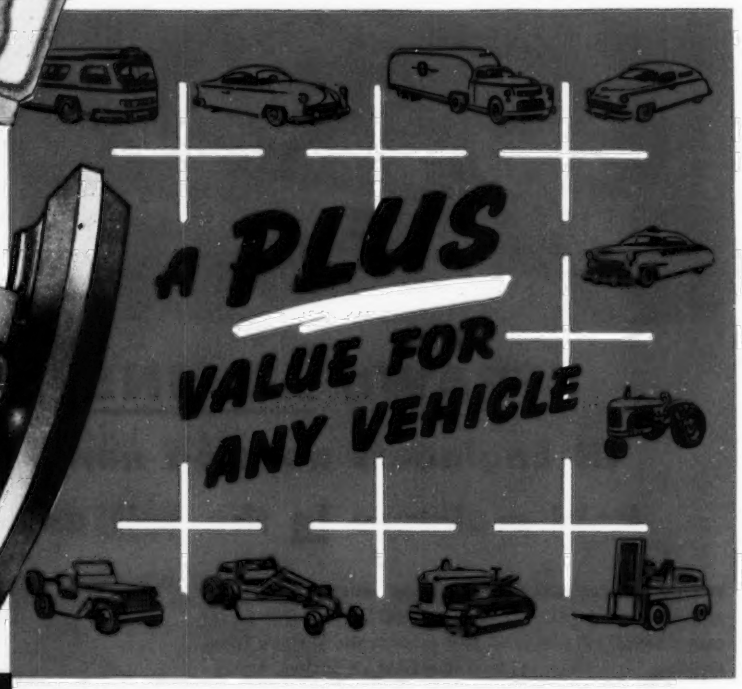

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• T-shaped oil-impregnated bronze ball separator maintains perfect concentricity—eliminates eccentric thrust, excessive wear—assures the plus smoothness, quietness and endurance of bronze-to-steel contact.

• Large, factory-packed grease reservoir assures lifetime lubrication—no need for costly grease fittings or oil lines.

• Special construction locks shell to free race, forming leak-proof joint. Lubricant can't escape to clutch facings, never needs replenishment.

• Case hardened races for wear-resistant working surface and tough, elastic, shock-absorbing core.

Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Miscellaneous Precision Parts.

In 1953, as in the past 19 years more of the nation's mobile vehicles will be equipped with the Aetna T-Type clutch release bearing than with any other type. Its unrivaled service life has always made it the most economical in the long run. Once installed it is trouble-free, attention-free for vehicle life. Thanks to its design and lubricant capacity there's no need of costly machining operations for oil lines or grease fittings—no need for further maintenance whatsoever. Think what that saves in man and machine hours on the assembly line, in saving up-keep costs for the vehicle owner.

It's a trusty sign of dependability and economical performance in any vehicle—the famous Aetna T-Type bearing. Investigate. Find out the many other sound reasons it deserves a place in your specifications.

AETNA BALL AND ROLLER BEARING COMPANY
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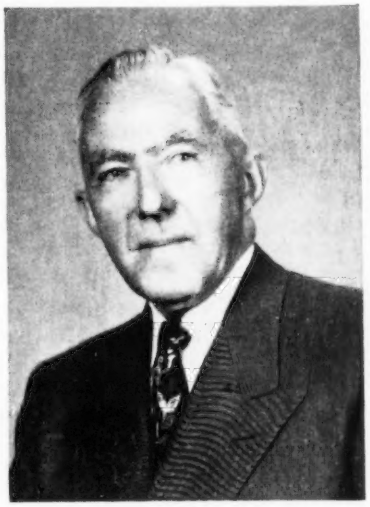
AGRICULTURAL ENGINEERING

VOL. 34 JULY, 1953 NO. 7

New Frontiers for Agricultural Engineers

Ivan D. Wood
MEMBER ASAE

IN THIS address I shall attempt to set forth what agricultural engineers have accomplished through the years since that day some 46 years ago when a group of serious-minded young men gathered together and conceived the idea of an agricultural engineering profession. In that group were some immortal names such as Davidson, Chase, Riley, and others well known to our profession. These men lived to see the profession and the society representing it develop beyond their fondest dreams. They could not have foreseen the great changes which have taken place in the last half century any more clearly than we can now foresee the happenings of the next half hundred years. We can only guess and reason and hope.



IVAN D. WOOD
President, ASAE, 1952-53

I should like to spend a little time in prophesy. My prophesy will of course be subject to change without notice, because I cannot tell what great discovery tomorrow's newspaper may report on its front page. I hope, however, that none of my listeners will ever cease to attempt a look into the future. The dreams you have today are often the realities of tomorrow. The laws of the universe are boundless and we have barely begun to discover and apply them.

Ten years ago we heard the physicists talk of nuclear reaction, of the transformation of matter into energy. We gave it scant attention until one morning a hundred thousand human beings died in a blast at Hiroshima and then again at Nagasaki.

Where do we go from here? Together shall we gaze a little into the crystal ball?

Rapid developments are taking place in the field of land reclamation and soil and water conservation. Some of these changes are being forced upon us by a population increase which may yet outstrip our ability to feed it if we maintain our present level of food consumption.

When I was a student at the University of Nebraska, the population of this country was slightly over 95 million. Our professor told us it might some day reach 130 million and remain somewhere near that figure. At the time of the 1950 census it was 150 million, and now stands at the amazing total of over 160 million, or did when I received the last estimate recently. The cropland of the nation has remained nearly the same in area for the last 10 years. We continue to remove land from production about as fast as we reclaim it. It is removed to make room for expansion of cities, for airports, for widening roads, for military depots and the many other things which modern civilization seems to need.

I do not profess to be a prophet, but anyone with a pencil can trace the ascending curve representing our population increase and arrive at the conclusion that the figure will reach 190 million or more by the year 1975. A careful study of our food-producing capacity and food needs of the future seems to arrive at the conclusion that we will need about 99 million additional acres of cropland or its equivalent in increased production of present cropland to meet the goal. A careful invoice of the probability of reaching this goal seems to leave us about 22 million acres short.

New frontiers for agricultural engineers in this struggle for food production will indeed be challenging. I believe we will bring irrigation water to every irrigable acre in the West irrespective of cost. We will no doubt irrigate many thousands of acres now thought to be non-irrigable by use of pipe lines from rivers carried many miles to supply sprinkler systems.

Heavy earth-moving machinery has changed our ideas about the preparation of land surfaces for irrigation and drainage. Not too long ago it required the lifetime of one or two generations to change the surface of a farm sufficiently to make surface application of irrigation water practical. Now the job can be done in a few days with carry-alls of 16 to 24 yd capacity and 115-hp engine to pull them. The faster-moving rubber-tired tractors bid fair to speed the job still faster and make it cheaper.

The larger and faster machines make it feasible to remove the top-soil, stockpile it, do the land leveling, and then put the topsoil back in place again. New ideas in land development for irrigation call for removing slope or reducing it to a minimum, then applying water quickly to the surface in order to obtain greater efficiency with less labor. Bench leveling and bench terracing will be the order of the day in the future of agriculture. Most nations which have

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Annual address of the President of the American Society of Agricultural Engineers before the 46th annual meeting of the Society at Pittsburgh, Pa., June, 1953.

The author—IVAN D. WOOD—is irrigation engineer, Soil Conservation Service, U.S. Department of Agriculture. Mr. Wood was the 1952 recipient of the John Deere Gold Medal awarded by the ASAE.

survived have retained the topsoil by these means, but it was done by laborious hand methods. Machines will make it possible to remove slope from much of our farm land in humid sections, making intensive cultural practices possible on areas which otherwise would necessarily be in grass crops most of the time.

It has been true throughout the world that nations, plagued by overpopulation, have turned from livestock and been forced to eat grain products direct. This I saw in Guatemala a year ago. With the exception of pigs and chickens there was almost no animals in that country. Humans acting as motors do most of the work. The lack of proper diet was everywhere apparent. Land was being successfully farmed by hand methods on slopes of 60 percent or steeper for thousands of feet up mountain sides. I believe one of the frontiers which agricultural engineers must move upon will be the food front. Will we be forced to become a grain-eating nation? I do not propose to say, but if we keep from it we must do a better job of saving what soil and water we now have.

NEED TO RECLAIM IRRIGATION SYSTEMS

In this country we have some 7½ million acres of cropland now supplied with irrigation ditches which for one cause or another are not being irrigated. Studies show that much of it is waterlogged from irrigation seepage, impregnated with harmful salts or lacks proper preparation. In some cases, irrigation systems have fallen into bad repair and the less productive areas have been allowed to go back to dry-land farming. The coming generation of agricultural engineers must find means of reclaiming those portions of this potential irrigation empire which are worth reclaiming. New methods of drainage more effective than those used in the past will have to be found.

I have been captivated by the work being done on electroosmosis. Electroosmosis is that magic created when electrical potential is applied to soils for the purpose of drainage. It makes water run up hill, coaxes it out of colloidal clay and even creates a new soil structure. Who can say but that with the coming of electrical energy from molecular power plants we will be draining the salts from some of our now hopelessly waterlogged swamps, the soil structure of which makes drainage impossible with present methods.

The science of applying water to the land is in its infancy. Most of our present-day methods are yet crude. We lose about 50 percent of the water getting it to the farm headgate, and less than 50 percent of the remainder gets in to the plant. There is great need for better methods of ditch lining, particularly for farm ditches. We need a lining so cheap that it can perhaps be discarded when ditch cleaning becomes necessary. A machine has been conceived which will shape a ditch cross section, lay a cheap waterproof membrane and cover it with dirt in one operation. Maybe aluminum foil has possibilities as a lining, or some other substance which a young agricultural engineer will find through research.

Perhaps ditches are the wrong idea after all, especially for a sub-humid area like eastern Nebraska and Kansas where irrigation will not be necessary every year. Maybe a light metal pipe system, which could be laid out in a hurry when dry weather makes an appearance, is the answer. Few farmers will maintain a complicated system of ditches and structures through three or four years of wet weather. The pipe could be put in the barn loft and put to use in a few hours.

In the future irrigation transportation systems will have to be made more efficient. As the need for water becomes more acute we will find ways of doing the job without the extravagant losses we now experience. The agricultural engineer is the logical man to do this job.

It is my conception that the design of irrigation systems of the future must give more consideration to the farm unit than has been done in the past. After all, irrigation exists for the benefit of the unit it is to serve and not to give some civil engineer the satisfaction of saying, "I have designed the biggest dam in the world." I would rather be the agricultural engineer who says, "I have designed a hundred farm units which irrigate with ease and efficiency and support 100 happy farm families."

Sometime we must stop cutting farm units into half a dozen pieces with ill-placed irrigation and drainage ditches, leaving dozens of odd corners to grow weeds and insect pests. Sometime we must learn to use the rich black dirt in the berms of irrigation and drainage ditches in our land-leveling processes. Then the farm operator will not be handicapped with unsightly canal banks growing a myriad of weed varieties. Sometime we must stop making land-consuming borrow pits and get the needed dirt from land-development processes.

RE-EVALUATION OF EROSION CONTROL NEEDED

In the soil conservation field there are some frontiers which need investigation. Agronomists are still trying to do with grass that which might better be done with permanent structures. Certain types of gullying can be temporarily halted by sloping and seeding, but the cure is temporary and lasts only as long as the farm is in the best of stewardship. There is now need for a revaluation of the whole subject of gully control, terrace outlets and some other phases of soil erosion control to determine how some of the so-called cures will stand the ravages of time, dry weather and change of farm ownership.

In the field of power there is room for vast improvement in efficiency of power production. So far we have been pretty well supplied with coal, oil, gas and wood, things made from the solar energy expended upon the earth centuries ago. As these products become scarcer or less economical to use, we will have to seek elsewhere and now is not too soon to start.

Our total energy utilization in this country is somewhere near 10 hp for each man, woman and child on duty 365 days per year 24 hours per day. Since a man is equal to about ⅒ hp, it appears we have increased our output about 100 times that of primitive man.

Energy conversion from fuel varies from 2 percent upward, but is probably seldom over 20 percent. The recovery of some of the lost 80 percent is a frontier which young engineers might investigate. An internal-combustion engine with a compression ratio of 12-to-1 would improve our efficiency by 30 percent. If this type of engine were now available, it would save 12½ billion gallons of our dwindling oil supply annually, according to C. L. McCuen, general manager of the General Motors Research Laboratories.

In the next period of engineering, we will hear much of

the gas turbine and the turbojet, maybe for tractor power and certainly for automobiles.

I believe the next generation will see a great use of solar energy as a source of power for everyday use. Many research laboratories are probing into its possibilities. I do not believe many persons have given thought to the tremendous amount of energy given off by the sun continuously. When it reaches the earth's surface, it is equivalent to that contained in 2000 tons of coal or 400,000 gal of oil, for each day, per square mile. At present the most practical way that this energy can be stored for future use is by chlorophyl in the photosynthesis of plant life. This process is not very efficient. A field of hybrid corn, yielding 100 bu per acre recovers about 0.5 percent of the annual sunlight used to produce it. A 14-ton yield of sugar beets per acre has been estimated to recover about 1½ percent of the total annual solar energy.

Some little progress has been made in storing solar energy in the solar house which uses sunlight to heat various substances during the day for use at night. Two scientists at the Massachusetts Institute of Technology announced recently a process of making hydrogen when sunlight was directed to solutions containing certain iron compounds. Now we are on the threshold of discovering the magic properties of chlorophyl and the means whereby this master catalyst does its work, a work without which no life would exist on this planet.

I believe a great frontier lies beyond the horizon of known and unknown metals. Such substances as titanium seem to hold great promise for future light vehicles. Titanium is about half as heavy as steel, yet is almost as strong. It is ductile yet resistant to many things which corrode steel. We have not made the use of aluminum which is yet possible. Lightness in irrigation structures has become an important factor as labor has become scarcer. In modern irrigation practice the farm operator often must do his farm work and run the irrigation at the same time. His portable irrigation must be light to facilitate this job.

PUBLIC RELATIONS AS A NEW FRONTIER

There is another frontier which agricultural engineers and as a matter of fact all other engineers must investigate and then proceed to do something about. We have done a lot of talking about it and all seem to realize its importance, yet we still refuse to take the matter seriously. I refer to the public relations angle, namely, our contact with fellow men —our means of basic communication, speaking, writing, composing. A better knowledge of good English and the ability to use it effectively would take us more freely and actively into public affairs. In my work this past year I have had an opportunity to talk to many industrial people as well as those engaged in affairs of state. No one ever seems to doubt the engineer's ability to use the right formula; they believe implicitly in his honesty; they praise his diligence, but usually end by saying, "Oh, if he could only talk in public," "If he could only write good reports," or "Would that he could spell."

I believe that this weakness with regard to public contacts has been a distinct disadvantage in many ways. It has put us in second and third place when executives are chosen in some cases. It tends to relegate us to the role of handy men—good to have around when a topographic map is needed or a special machine designed. Before we go too far in our criticism of those who seem to have left us out in the cold in many cases, we should examine our own house and put it in better order.

For years now I have sat in our ASAE annual and winter meetings and heard men of supposed national prominence read papers in a monotone too low to be heard beyond the first four rows. I have seen charts and slides so complicated that even the speaker got hopelessly mixed up in trying to explain them. It seems hard for engineers to learn that there is as much know-how needed to prepare good slides and charts as there is in designing a dairy barn, or that public speaking is something other than saying the words.

In the January issue of *Magazine Digest* there is a very interesting article, entitled "Are Car Manufacturers Our Real Killers?" This article seemed to me to open wide another frontier for engineers, engineering for safety. No one reading this article can help but be impressed with the disregard with which safety has been treated in our modern car design. An analysis made by the *Denver Post* of car accidents in 1952 for Colorado, showed that of the 380 people killed 121 could have been saved by the simple expedient of a crash belt. So simple and harmless an appearing thing as a pop bottle in the back window ledge of a car can become a projectile, on sudden stops as occur in a head on collision, with sufficient force to crush a human skull. Baggage in the trunk can shear off the legs of helpless victims in the car seat. It is a question how long the public can be beguiled by fancy streamlining, more horsepower and chrome finishes.

THE AGRICULTURAL ENGINEER HAS A SAFETY JOB

The agricultural engineer has a job to do in regard to farm safety. C. L. Hamilton of the National Safety Council says, "Farm tractors are being sold faster than safe tractor operation." He says that at present 87 percent of all tractors on farms are of the wheel type, 7 percent of the garden variety, 4 percent are of the track-type and 2 percent are homemade. In 1950 there were 640 fatal accidents with wheel-type tractors. Reports seem to indicate that the total number of such accidents is increasing by about 40 each year, but the rate per 100,000 tractors is not increasing. Statistics are not readily available on non-fatal accidents but the National Safety Council estimates that they range in number from 20,000 to 30,000 annually. Over one-third of all fatal tractor accidents in Iowa from 1949 to 1951 were on the highway, yet the tractor spends a small percentage of its working hours on the highway. The reasons given were slow-moving vehicles merging with fast road traffic, operating the machine at excessive speeds, ignoring rules of the road, and improper tractor markings.

The engineer of the present and of the future should ask himself, "Are we getting too far ahead of the human body with our complicated machines?" Human evolution is a slow process. We have about the same body as that possessed by primitive man. We have been thousands of years losing our big toe, but we still have it. We have been walking upright for thousands of years, but our internal works still revolt at the idea and would probably work better if we traveled on all fours.

Are we on the threshold of a new type of engineering which we might call human engineering? Our world of gadgets has become too complicated for the majority of humans in some fields. My son, *(Continued on page 458)*

Grain Cooling by Air

W. V. Hukill
MEMBER ASAE

ONE of the difficulties encountered in storing grain for more than a few months is the migration of moisture to the upper layers. The cause of this moisture movement and its effects are discussed briefly in a paper, entitled "Mechanical Ventilation of Stored Grain" by Robinson, Hukill and Foster, in AGRICULTURAL ENGINEERING for November, 1951. This paper discussed the conditions under which moisture migration occurs and its effect on the condition of the grain. It also discussed equipment for controlling moisture movement that has been used in large buildings of 30,000 to 50,000-bu capacity by the federal government in its grain-storage program.

When grain is stored in large bulks and held from the summer through the following winter, the differences in temperature between various parts of the grain pile set up convection currents throughout the grain and vapor-pressure differences between the grain in different parts of the pile. As a result, there is a slow but continuous exchange of moisture from the grain in the warmest section to that which is cool. The increase in moisture usually occurs at the top surface of the grain pile and may become noticeable early in the fall as atmospheric temperatures have started to drop.

Usually no serious damage is done until midwinter, although sometimes excessive moisture content in the upper surface can be noticed early in the fall. In grain bins of less than 1,000 bu or so this effect is seldom very serious because the grain mass is so small that large differences in temperatures between interior and outer layers of grain do not develop.

In the large flat storages used for government-stored corn, many of which were used starting in 1949, this difficulty was anticipated and ventilating tunnels were installed in the storages before they were loaded. Air circulation through the grain was furnished by electric or gasoline-powered fans to draw atmospheric air downward through the grain during cool or cold weather thus facilitating the more of less uniform cooling of the whole mass of grain. The rate of ventilating in these bins was mostly in the neighborhood of 0.1 cfm per bu of grain. With this volume of air circulating it was possible to reduce grain temperatures through a large part of the grain mass sufficiently to prevent trouble by ventilating for a period of 4 or 5 days to a week.

A large number of storages having capacities from 3,200 to 10,000 bu were erected and filled with corn. These were not equipped for cooling by ventilation. Last winter the grain in some of these storages of intermediate size gave considerable trouble on account of moisture movement to the surface. The usual treatment consisted of stirring the surface with a rake or fork, breaking up the caked surface, or in extreme cases removing the grain from the upper part of the bin and disposing of it. This procedure requires considerable supervision and labor and does not correct the trouble even though it may temporarily reduce the seriousness of spoilage.

Last winter in Greene County, Iowa, many of the 10,000-bu bins were requiring a great deal of attention and an attempt was made to cool the grain by mechanical ventilation. These are circular wooden bins 30 ft in diameter and 16 ft to the eave. The walls are lined with roll roofing to prevent the penetration of storm water. By January some of these bins had become badly infested with insects, the surface moisture was high and frequently the underside of the roof would be wet from condensed moisture arising from the warm interior grain. The insect population had become great enough to raise the temperature of the interior grain to between 100 and 105 F. Temperatures within the grain pile of between 100 and 105 F are observed fairly frequently, but rarely, if ever, are they found higher than this. Raking the surface of such a bin loosens the grain and may interfere with the activity of a few insects on the surface, but condensation of moisture usually continues after raking and a bad bin must be given repeated attention. If a few hundred bushels are removed from the surface of the grain, the same situation is likely to develop on the newly exposed surface unless the heat of the grain below is controlled.

These bins were not equipped for air circulation and it was necessary to install some duct work if the grain was to be cooled. It is expensive to empty and refill a bin, and several methods of inserting air ducts without emptying the bins were attempted. It was found that by making an opening in the wall of the bin near the ground a perforated pipe could be pushed horizontally into the grain. Several bins were equipped with horizontal pipes in this manner. The pipe was perforated so that if air was exhausted from the pipe a downward flow of air through the grain from the upper surface would be induced. In order to get a sufficient movement of air, the fan of a pneumatic grain conveyor was used to draw air out of the pipe. The fan was powered by a 25 to 30-hp gasoline engine. A negative pressure up to 12 to 14 in could be created using this equipment. Lower capacity fans were also used. It was found that by operating the large capacity fan for 4 or 5 days to a week sufficient cool air was drawn through the grain to reduce the temperature to about 50 F. The heavy equipment required for inserting the pipes and creating the air flow made this a cumbersome operation. It was found that the air circulation by this method was not as effective as it should have been for the following reason. Even though the negative pressure inside the perforated pipe may have been very high, most of the pressure drop was used up in drawing air through the perforations in the pipe and through the layers of grain immediately surrounding the pipe. The downward movement of air through the mass of grain as a whole was actuated by a very small negative pressure. The corn near the sidewalls being cold and that in the center of the bin being warm, there was a tendency for most of the induced air movement

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to take place around the sidewalls of the bin, and at the center of the bin the flue action due to the high temperature tending to move air upward was almost as great as the pressure tending to move the air downward. The result was that most of the air drawn out of the pipe came down through the grain in the parts of the bin near the sidewall where the grain was already cooled. That in the center of the bin was ventilated very poorly and it took a long time to cool the center column of the grain.

This method was effective in cooling the grain but was expensive in equipment and power and labor.

A SECOND METHOD OF COOLING GRAIN

A second method of cooling the grain was attempted. In this case perforated pipe 4 in in diameter was sunk vertically in the grain from the top surface in the center of the bin. The perforated pipe was completely immersed in the grain and connected to a solid pipe of the same diameter which extended up through the surface of the grain. The perforated section of the pipe was usually 4 to 8 ft long, and it was found that the pipe should be solid to about 3 ft below the surface of the grain. The intake from a small centrifugal fan was connected to this pipe and the exhaust from the fan was piped to discharge outside the bin. With this arrangement it was found that with a ⅓-hp electric motor the central region of a heating bin could be cooled in about a week. A number of bins were treated in this manner and gave no further trouble. The grain in one bin, however, after having been ventilated for a few days and the temperature down to a depth of about 8 ft having been reduced to 50 F or below, still had a pocket of warm grain that had not been reached adequately by the ventilation. About four weeks later the grain above this hot spot had also heated and moisture was again accumulating at the surface.

These tests indicated that mechanical ventilation during cold weather could be a useful way of treating the accumulation of moisture in the upper layers. They indicated also that in order to be permanently effective the treatment should leave no heated spots in any of the grain.

One interesting observation was that after the cooling had proceeded for a few days large numbers of insects were drawn through the pipe and discharged through the fan. The collections of insects caught in a cloth bag attached to the discharge pipe indicated that as the grain cooled the insects tended to move toward the areas that were still warm and eventually found themselves at the perforated pipe and in the air stream.

The insertion of the vertical pipe for this purpose in a bin already filled was accomplished without much difficulty by pushing the pipe down and using either the suction of a pneumatic conveyor or a household vacuum cleaner for drawing the grain out of the inside of the pipe as the pipe was pushed down. Without removing the grain from the pipe as it is pushed downward, a great deal of pressure would be required and only very heavy pipe would withstand the pressure required to insert it. Ordinary galvanized-iron 4-in gutter spouting can be inserted to a depth of 10 to 12 ft if the grain is withdrawn as the pipe goes down.

The treatment described above appears to be a practical method of preventing further damage after a bin of corn has begun to go out of condition, on account of moisture migration. The question arises, however, whether the trouble can be prevented before it has started, and can it be done on a practical and economical basis in a routine manner? If so, a substantial source of reduced quality in stored corn could be eliminated and the nuisance and expense of raking, fumigating and disposing of small lots of grain on account of imminent damage could be reduced greatly.

This season a number of bins of government corn at various locations have been equipped for mechanical ventilation for this purpose. This is being done in Indiana, Nebraska and Iowa and possibly in other states as well. Following is description of the tests underway in Iowa:

Bins at three sites in Iowa—Cooper, Scranton and Ames have been equipped with mechanical ventilators. Electric fans have been installed in about 30 bins. In general, the ventilating pipes are about as described for last year's cooling. Five-inch perforated pipe is used in most of the bins. There is variation in pipe diameter and in the depth of insertion, but usually about 9 ft of pipe is inserted vertically in the grain. The lower 6 ft of pipe is perforated. Small centrifugal electric fans are mounted to draw air out of the pipe and discharge it outside the bin through a 3-in gutter pipe. The fan motors use from 35 to 50 w and move from 50 to 100 cfm of air. With this air volume they are not expected to cool all the grain quickly. In a 10,000-bu bin the air circulation is only 0.01 cfm per bu or less. The fans were started in September and October and will be operated continuously throughout the winter. It is hoped that, even with this small volume of air circulation, moisture migration will be controlled in two ways. First, during the period when the fan is operating, any tendency for an upward convection current at the center of the bin will be counteracted by the suction from the pipe and no warm air will move upward to the surface and contact cold grain there. Second, by continuous operation the grain will eventually be cooled in the center of the bin, thus eliminating the tendency for convection to take place. Meanwhile any insects present will find it more difficult to build up large population and induce hot spots.

ONE CHARACTERISTIC OF MOISTURE ACCUMULATION

Some of the bins under observation are round wooden ones as described above and some are 18-ft round steel bins about 15 ft deep, holding 3,200 bu. In addition to the electric fans a few wind-operated suction ventilators have been installed on other bins. They are connected to perforated pipes buried in the grain in about the same way as the electric fans. The air circulation in these bins will of course depend on the wind and will be continuous though of variable intensity as long as the wind is blowing.

One of the characteristics of the moisture accumulation in upper layers is that where the grain surface is uneven, the highest grain in the bin tends to be most affected. For this reason the grain is usually leveled off after filling, and it is not practical to fill the bin above the eave. In the 30-ft bin, 800 to 1,000 bu more grain could be put in the bin if it were heaped up in the center. A few of the ventilated bins have been filled to capacity to see if the air circulation will permit this kind of loading without danger of damage. If so, the practical storage capacity can be increased by about 8 to 10 per cent.

Conclusions as to the effectiveness of this method of cooling cannot be made until January or February. After about four weeks of ventilation all of the bins have cool grain at the upper surface at the center. Some which have

high-temperature grain and insects down below have shown some tendency to caking at the surface near the outer walls. Some of the bins had grain temperatures of 90 to 100 F during late summer. Temperature records will be taken and samples for grain quality and moisture readings.

The cost of making the installation including fans, pipes, connections, installation and wiring for electricity is estimated to be between $50 and $75 per bin.

* * *

Since the foregoing report was presented in December, observations have continued. The temperatures in the 18-ft bins, both ventilated and unventilated, reached 30 to 40 F. In the 30-ft bins temperatures near the floor reached 40 to 50 F in both ventilated and unventilated bins.

The effect of the ventilation is probably best illustrated by the records of grain moisture at the upper surface of the grain at the center of the bin. Table 1 shows the moisture content of samples taken from the bins at this point. The migration of moisture has been reduced substantially.

Other moisture samples were taken, and in the 18-ft bins with fan ventilation the entire surface was about like the center of the bin. In the 30-ft bins, however, some of the ventilated ones had areas of caked and high-moisture corn midway between the center and the walls. From these observations it appears that 50 to 100 cfm of ventilation in a 3200-bu 18-ft-diameter bin is adequate for the purpose. This rate of ventilation in the 10,000-bu 30-ft-diameter bins did not prevent all moisture migration to the surface. While the tests did not include a complete range of air volumes for selecting the optimum, it is estimated that 150 to 200 cfm of continuous ventilation through the fall and early winter would be a desirable rate for practical operation in the 10,000-bu bins.

TABLE 1. AVERAGE MOISTURE CONTENT OF CORN FROM TOP FOOT OF GRAIN AT CENTER OF BINS WITH AND WITHOUT VENTILATION

	30-ft round bins		18-ft round bins	
	Non-ventilated	Fan-ventilated	Non-ventilated	Fan-ventilated
Feb. 1, 1953	17.1(10)	14.0(21)	19.2(4)	14.3(5)
March 15, 1953	22.0(10)	14.4(22)	18.8(4)	15.1(5)

NOTE: The numbers in parentheses are numbers of bins contributing to the average moistures shown.

New Frontiers for Agricultural Engineers

(Continued from page 455)

who is a graduate mechanic in the U.S. Air Force, is engaged in the design of complicated equipment which tests the ability of cadets to respond to supersonic speeds and to shoot correctly at planes diving at all angles. Many are eliminated at the start to pursue less speedy occupations.

One of our new frontiers will be the design of safer machines with which accidents will be practically eliminated.

Human engineering has already gone a considerable way. Many of the larger companies are actively investigating its possibilities for reducing accidents and improving worker efficiency. Studies are being made to improve voice communication, and explorations are being made as to the natural way in which the human body interprets dial readings and then reacts to move controls to accomplish a desired result. Studies of military aeroplanes have shown that many cases of pilot error resulted from the placing of controls near together so that the wrong one could easily be activated. It has been shown that all controls should suggest the desired actions. If it's wheels down, the control lever should go in a down direction. All toggle switches should be up for an "on" and down for an "off." Altimeters should show only a portion of the dial with the readings in figures which cannot be mistaken.

The job of the human engineer will be twofold: fitting man to the machine and the machine to the man. The automatic machines which are coming into being with each day open up a host of new problems. Just what role will man play in the complex machine system? Will he become just a monitor? Should he be used as an integrator of sensing mechanisms? Will we in the future have mechanisms capable of giving the right administrative decision when fed all the known facts on a tape? I am sure I do not know and would not like to say that such will be an impossibility. One thing is sure, psychology has definitely entered the engineering field and the agricultural engineer of the future will need a working knowledge of it. Machines of the future will be made to operate more automatically. Automatic pilots will help the outclassed human body to eliminate errors in judgment and operation, just as radar helps the jet pilot to aim his machine guns at speeds exceeding 1,000 fps.

We have already entered the automatic age in machine design in many fields. Two weeks ago an atomic explosion was detonated in Yucca Flats, Nevada, but human hands did not pull a trigger. A vastly complicated device correlated the many things which had to be timed to a split second. Hundreds of electrical relays clicked away as rockets were fired, camera shutters were opened and closed in a succession of photographs, heat and radio activity were measured and a vast number of other scientific data gathered without human touch. Our complicated system of street signal lights in Denver are operated by an electric brain which cost $30,000. It measures the traffic flow at all times of the day and regulates the lights by means of electric eyes. If east and west traffic is heavy, the lights are on a longer green signal in that direction. It can even measure the pedestrian traffic and give them a longer walk light if needed.

It is well to keep in mind the fact that our wonderful machines do not design themselves. Our new computers may do the work of a hundred mathematicians, but they can only do what the mind of man feeds into them.

The tale is told of an official of the patent office who wanted to resign many years ago because he said that about everything worth inventing had been invented. How ridiculous this seems today, and yet we are probably as far from the ultimate goal today as we were at that time. Each new discovery brings new horizons and new frontiers into view. Never in the history of mankind has there been more opportunities for a young man with vision. There is no end to the road of discovery. Man's final destination is determined only by his imagination and a will to make his dreams come true.

Comparison of Two Methods of Estimating Consumptive Use of Water

Byron R. Tomlinson
MEMBER ASAE

ONE of the most important factors to be considered by irrigation engineers attempting to allocate irrigation water to a given area is the consumptive irrigation water requirements of the crops to be grown in the area. The total amount of water required at the farm headgate is the consumptive irrigation requirement plus reasonable and necessary losses incident to conveying and applying the water to the land.

After determining the amount of irrigation water required at the farm turnout, it is a simple matter to sum up the number of farms being served by any one canal, increase this sum by the losses expected from the canal, and from these values design the size of canal which will carry the required irrigation water for the area.

Several methods are currently being used to obtain this consumptive-use estimate in the design of irrigation projects. Two of the most commonly used procedures for making these estimates are the Lowry-Johnson method and the Blaney-Criddle method.

During the 1951 season, the author made some detailed studies on consumptive use of water in the Pinedale area of the Green River Basin of Wyoming. This paper is a comparison of the accuracy of the above two procedures as compared with the actual measurements made during the growing season.

Although the methods of estimating consumptive use are based on the normal year, a comparison of the factors reveals little difference between the 1951 season and the normal year. Therefore, it is assumed that the 1951 season is a normal year.

In order that the reader may have some idea of the methods used, the important considerations as they apply to the Green River Area are presented here. The area studied is at an elevation of 7100 ft. The climate is severe in winter, with a good snow cover generally present. Summer temperatures reach 90 F, but frosts frequently occur at night in every month.

Lowry-Johnson Method. The length of the growing season as defined by the Lowry-Johnson method was obtained by using mean daily temperatures and plotting them as five-day moving averages (Fig. 1). The ends of the growing season are thus defined by the dates between which the smoothed temperatures remain above 32 F. This method indicates a 92-day growing season for the Pinedale, Wyoming, area during 1951. The calculation of day-degrees Fahrenheit for this growing season, using maximum temperatures, is as follows:

Calculation of day-degrees

June 12-30	848 F
July 1-31 (48.0 x 31)	1488
August 1-31 (46.9 x 31)	1454
Sept. 1-11	504
	4294

or "effective heat" of 4.294

By using the graph shown in Fig. 2 and an "effective heat" of 4.294, the total amount of water required for native hay production becomes 1.51 acre-feet per acre or approximately 18 acre-inches per acre.

Blaney-Criddle Method. The Blaney-Criddle method is based on the following three major assumptions:

1 Consumptive-use varies directly with the average temperature, the available sunlight hours, and for the longer-growing crops, with the growing season.

2 All annual crops are usually planted at the beginning of the frost-free period. (In the Pinedale area, the native hay meadows probably begin growing earlier than annual crops because no planting is necessary.)

3 Normal precipitation during the growing season is believed to be consumptively used by the crops; it decreases

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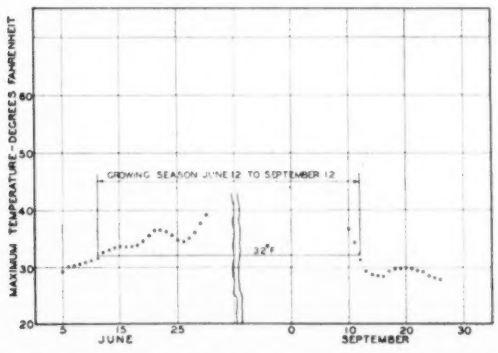

Fig. 1 Determination of the growing season by the Lowry-Johnson method for the 1951 season

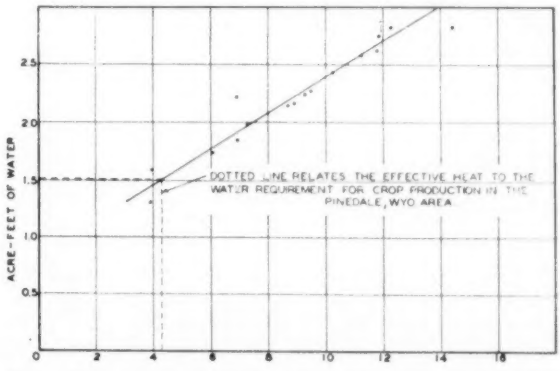

Fig. 2 The relationship between the effective heat and water use. (Data from Lowry-Johnson method)

the irrigation requirements by the amount of precipitation. (This may be contrary to conditions found in southwestern United States, but a rainstorm in Wyoming, regardless of how small, usually is accompanied by considerable cloudiness, during which the decrease in plant transpiration tends to compensate for water losses as evaporation from the moistened soil surface, or as surface runoff.)

The following data, obtained from U.S. Weather Bureau records is used to calculate the consumptive-use:

TABLE 1. DATA FROM THE UPPER GREEN RIVER BASIN
Elevation, 7180 ft. Length of growing season, June 23—August 24, 62 days*. Latitude, 42°52'N. Average at Pinedale, Wyoming

Month	t† deg F	p‡ percent	f§	r‖ in
June	52.8	10.28	5.43	1.16
July	60.3	10.41	6.27	1.02
August	57.4	9.65	5.54	1.05

*U.S. Department of Agriculture Yearbook, 1941

†t = Mean monthly temperature as recorded in the U.S. Weather Bureau's annual summary—1948. Average of 31 years of record.

‡p = Percent of daytime hours of year for each month determined from Sunshine Tables, edition of 1905, U.S. Weather Bureau Bulletin No. 805.

§f = Consumptive use factor = $(t \times p)/100$.

‖r = Mean monthly precipitation as recorded in the U.S. Weather Bureau's annual summary—1948. Average of 34 years of record.

Using the data presented in Table 1, the following were calculated for the crop season at Pinedale, Wyo., during 1951:

Month	f	r, in
June (23-30)	1.26	0.27
July	6.27	1.02
August (1-24)	4.28	0.81
	11.81	2.10

The formula used by Blaney-Criddle for calculating consumptive-use is $U = KF$. when U = consumptive-use, K = consumptive-use coefficient, and F = consumptive-use factor. The consumptive-use coefficient K for the more important irrigated crops is determined by comparison with areas in the West. For native meadow hay, which is the principal crop in the Pinedale area of Green River Basin, the consumptive-use coefficient has been designated by Blainey and Criddle as 0.75.

If we multiply 11.81 by 0.75, a consumptive-use water requirement of approximately 8.9 in is obtained. If we subtract the 2.1 in of rainfall from the 8.9, a result of 6.8 in is obtained. This is the amount to be applied to the soil by irrigation water for crop production.

Data in Table 2 were obtained from "Wyoming Agriculture" for 1951 for the Pinedale Area.

TABLE 2. FROST DATA AND LENGTH OF GROWING SEASON

Frost data		Growing season		
Average date				
Last killing in spring	First killing in fall	Latest date of killing frost in spring	Earliest date of killing frost in fall	Average length, days
June 23	Aug. 27	July 14	July 31	65

The above table is presented to show the exact growing season for comparison with the normal which is 62 days.

Actual Measurement. The best yield data available for comparison with the calculated consumptive-use values is the yield of 1950 which was 0.88 tons per acre for the Pinedale area. For the comparison used in this paper, it is assumed that an average yield for the Pinedale area is 0.90 tons per acre.

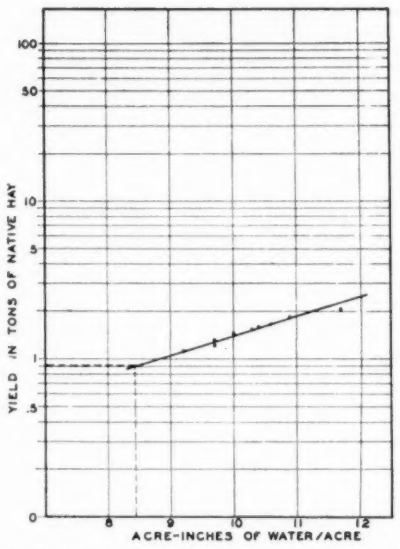

Fig. 3 Total amount of water to produce a given yield in the Pinedale area during 1951

Fig. 3 shows the total amount of water required to produce a given yield of native meadow hay in the Pinedale area. This curve is a summary of surface measurements and soil moisture determinations taken on native vegetation in the Pinedale area during the 1951 growing season. The yields shown on this figure were increased above the average for the area by using commercial fertilizers and improved water control. Deep percolation losses were eliminated by including only the water extracted in the root zone to arrive at the consumptive-use. The rainfall during the growing season was 1.8 in and this value is reflected in the consumptive-use curve.

The hay yields used in Fig. 3 were obtained on an oven-dry basis and then converted to hay at 12 per cent moisture. By using Fig. 3 to obtain the total amount of water used to produce a yield of 0.9 tons, a value of 8.4 acre-inches per acre is obtained.

Comparisons. Calculations by the Lowry-Johnson method show an annual consumptive use of 18 in. This is greater than twice the amount of consumptive use of water that was actually required during the growing season. This method also allows for a 92-day growing season which is approximately 50 per cent greater than the mean annual growing season of 62 days or the 1951 growing season of 65 days as used by the Blaney-Criddle method.

Calculations by the Blaney-Criddle method give a water requirement of 8.9 in for the growing season. By comparing the 8.9 in with the measured of 8.4, it is seen that the computed amount was only 0.5 in greater than the measured. However, since the computed is slightly above the measured, this method provides a small factor of safety. It is very close when all the factors are considered. If the average yield were 1.0 ton per acre, the measured amount and that computed by the Blaney-Criddle method would have been in exact agreement. However, the water use figure of 8.9 in as calculated by the Blaney-Criddle method is only 6 per cent greater than the measured amount of 8.4 in.

(Continued on page 464)

Corn Shelling with a Combine Cylinder

D. F. Hopkins and Geo. E. Pickard
ASSOC. MEMBER ASAE MEMBER ASAE

THE mechanical corn picker has been a boon to American agriculture, but it has had its day and should give way to better methods of harvesting. The picker looses more of the crop than does the combine, and it is responsible for four times as many accidents.

The main reason for the greater efficiency of the combine appears to be that it takes the whole plant inside the machine where it processes it. Corn should be harvested in a similar manner. Thus one of the reasons for the study reported in this paper on adapting the combine for harvesting corn was to take advantage of the combine's basically efficient principles. Other reasons were to take advantage of the combine's safety features and to reduce the farmer's investment in machinery.

The immediate objectives of this study were (1) to determine whether the combine cylinder and concave can be made to shell corn satisfactorily at normal moisture levels, (2) to determine concave and cylinder design and the best range of adjustments for shelling, and (3) to form some idea of the forces to be expected as compared to those encountered in the threshing of small grains.

It is believed that shelling is the crux of the corn-combining problem. It should not be too difficult to feed the cornstalks into the machine and separation should not present any particular problem, but if the combine cylinder cannot be made to husk and shell properly, then we shall have to think in terms of a new corn-harvesting machine.

EXPERIMENTAL SETUP AND PROCEDURE

The first experiments in shelling were made in the laboratory in order to have a longer test season and to permit a wide range of concave adjustments. As shown in Figs. 1 and 2, a rasp-bar cylinder and a concave were set up in a box in such a way as to permit variable concave opening front and rear. A variable-speed drive was used.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Power and Machinery Division.

The authors — D. F. HOPKINS and GEO. E. PICKARD — are, respectively, research assistant and professor, agricultural engineering department, University of Illinois.

After two seasons of shelling experiments the concave mounting was altered as shown to permit study of the forces involved in shelling. One end of the concave was left free to swing on one loose bolt. The opposite end, at which the corn was fed in, was supported by two parallelogram linkages as shown in Fig. 2. The horizontal and vertical forces are carried by the cantilever beams which are fitted with SR-4 strain gages. Resultant peak forces were calculated by combining the horizontal and vertical components taken from the Brush recording oscillograph.

For each shelling test, twelve stalks were fed in tassels first and one by one. For the studies of the forces on the concave, groups of three plants were fed in, at 40-in intervals, by a conveyor with a speed of 2 mph in order to simulate field feeding conditions.

A high-speed moving picture camera and a still camera with $\frac{1}{2000}$ sec strobe-light exposure were used to study the mechanics of husking and shelling. Fig. 3 shows a previously husked ear being shelled. Five blows of a cylinder bar or approximately $\frac{1}{15}$ sec is about par for the shelling job.

Slow-motion pictures (64 frames per second) show that the ear is easily and rapidly husked when it approaches the cylinder shank-first. For this reason there is some advantage in having the corn plants approach the cylinder tassels-first, since at harvest time the ears are generally pendant. However, it is highly desirable to be able to handle the crop in any position, particularly if an auger-type combine is being used, and the manner of approach of the ears appears to have little importance.

The following results are from 152 shelling tests made in three seasons' harvest and 40 tests of forces on the concave.

SHELLING EFFICIENCY AND KERNEL DAMAGE

Cylinder Design. The regular six-bar cylinder did not give satisfactory results. Corn was left on the cob, apparently by being carried through between adjacent cylinder bars, and thereby escaped contact with the concave. Two remedies were used: (1) Extra cylinder bars were mounted between the regular ones; (2) filler plates were mounted

Fig. 1 *(Left)* Cylinder and feeder arrangement for laboratory experiments in shelling corn • Fig. 2 *(Right)* Concave mounted to measure horizontal and vertical forces

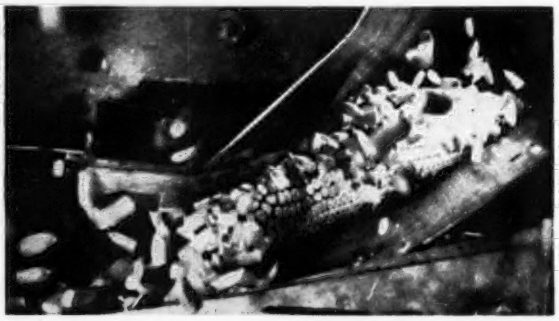

Fig. 3 This picture shows corn shelling action. Cylinder speed, 600 rpm. Exposure, 1/2000 sec with strobe light

between the cylinder bars to keep the ears in contact with the concave. Figs. 8 and 10 show that the 12-bar cylinder gave the lowest shelling losses while Figs. 7 and 9 indicate that the 6-bar cylinder with filler plates damaged the corn less.

Concave Screen Openings. The largest standard openings for this concave were ¼ by ¾-in. A new screen was made with ¾-in round holes. This screen doubled the amount of corn falling through the concave (to 60 percent) but had no measurable effect on kernel damage.

Number of Concave Bars. When the number of concave bars was increased, trouble was experienced in feeding. It became more difficult to get the corn stalks to go around the curve. It appears that the number of concave bars should be kept to a minimum consistent with acceptable shelling.

Angle of Approach to the Cylinder. It was found that for best feeding the line of the feed apron should be as nearly tangential to the cylinder as possible. The angle of approach appeared to have no effect on shelling efficiency.

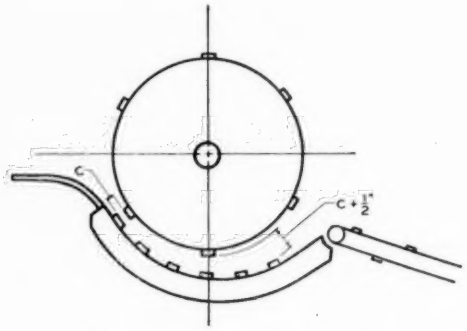

Fig. 4 Diagram of concave adjustment

Effect of Concave Clearance and Cylinder Speed on Shelling Efficiency and Kernel Damage. Fig. 4 shows diagrammatically the type of concave adjustment that was used for most tests. It was found early that the wedging or funneling effect provided by the large opening at the front of the concave was a great help in getting the ears and stalks to move through. There was also less breakage of the cobs. As a general rule, throughout these tests less corn was lost if the cobs were not split, since split pieces were small enough to slide through with the kernels still attached.

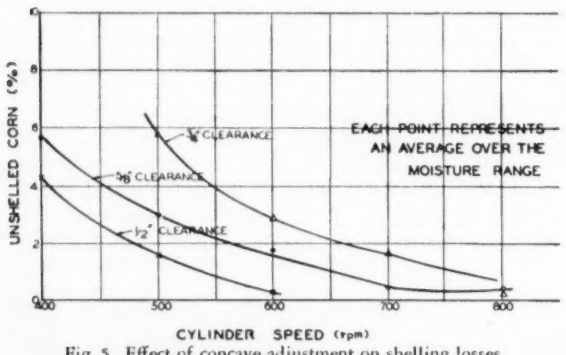

Fig. 5 Effect of concave adjustment on shelling losses (12-bar cylinder)

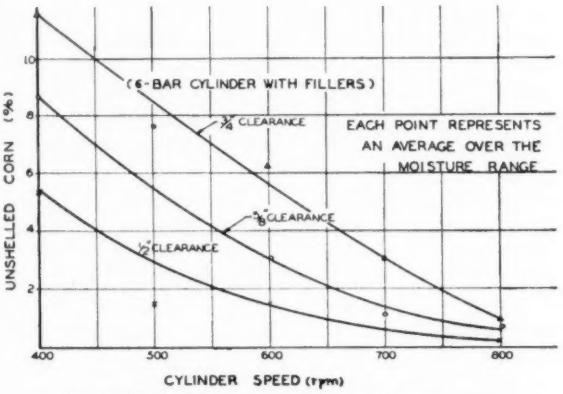

Fig. 6 Effect of concave adjustment on shelling losses (6-bar cylinder with fillers)

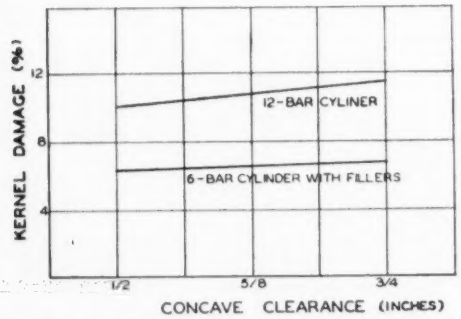

Fig. 7 Effect of concave clearance on kernel damage

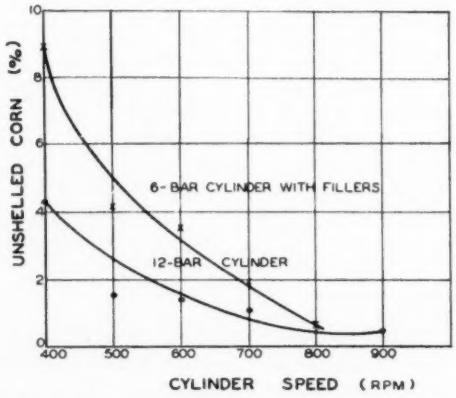

Fig. 8 Effect of cylinder speed on corn losses (average of all tests)

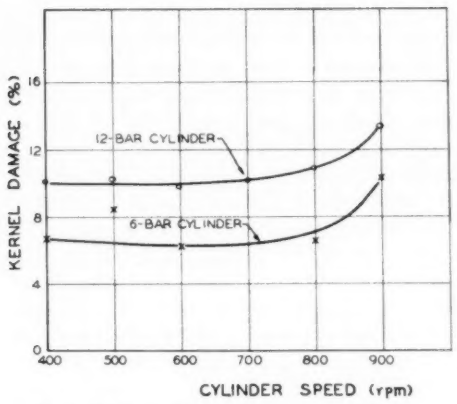

Fig. 9 Effect of cylinder speed on kernel damage (average of all tests)

Fig. 5 shows the effect on shelling losses when a 12-bar cylinder is operated with different concave clearance (measured at the rear) and at various speeds. As would be expected, shelling losses decrease with higher speeds and with smaller clearances. At higher speeds none of the concave adjustments caused excessive shelling losses. However, it was difficult to get the cylinder to take the stalks rapidly enough at openings of 0.5 in and less. In addition, the stalk was chewed up considerably and this would tend to cause trouble with plant sap in the machine.

Results of varying speeds and clearances were about the same when a cylinder with fillers was used as when a 12-bar cylinder was used (Fig. 6).

While shelling efficiency at any given speed falls off as the concave is opened, kernel damage is almost constant throughout the range from ½ to ¾ in, as shown by Fig. 7. Apparently most of the damage occurs in shelling the corn

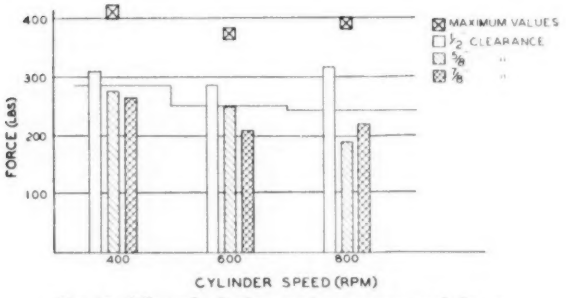

Fig. 12 Effect of cylinder speed on average peak forces

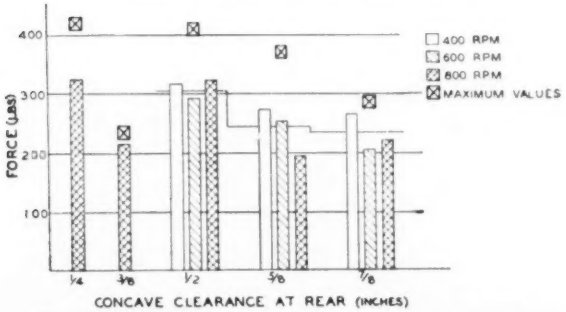

Fig. 13 Effect of concave clearance on average of peak forces

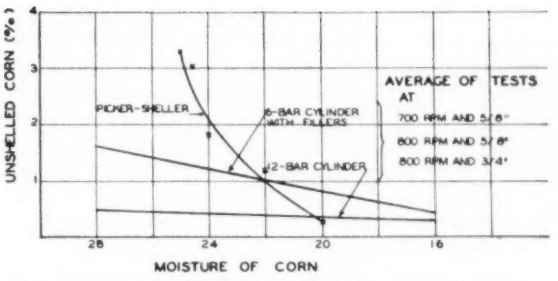

Fig. 10 Relationship between kernel moisture and unshelled corn

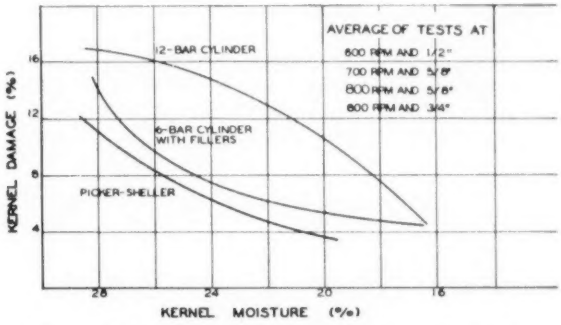

Fig. 11 Relationship between kernel moisture and damage

from the cob rather than in passing it through after shelling. Less damage results from the use of the fillers.

Fig. 8 shows again the effect of speed on shelling efficiency and indicates that the 12-bar cylinder shells more effectively than the regular cylinder with the filler plates. These are averages of all clearances and moisture conditions and therefore do not indicate the best shelling job that can be done, even though some losses drop to as low as 0.5 percent.

It is interesting to note in Fig. 9 that kernel damage is almost constant for speeds up to 800 rpm, after which it rises rather rapidly. Again because these are averages of all tests they are higher than can be achieved with the "best" settings.

Effect of Kernel Moisture on Shelling and Damage. Fig. 10 shows the relation between kernel moisture and shelling efficiency. For comparison, tests figures* for a picker-sheller are given. The combine cylinder appears to be less sensitive to high kernel moisture than the picker-sheller, and shelling losses compare favorably.

*From a paper, entitled "Results of Performance Tests of a Picker-Sheller," by D. E. Burrough and R. P. Harbage, Purdue University, presented at the winter meeting of the American Society of Agricultural Engineers, December, 1951.

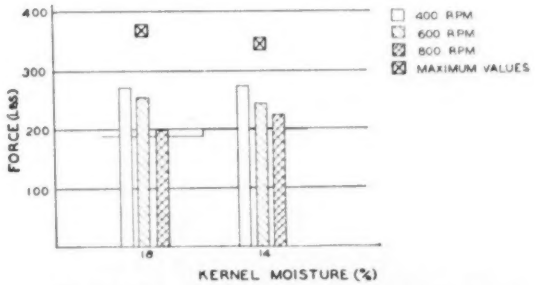

Fig. 14 Effect of kernel moisture on average peak forces

Fig. 11 indicates that the combine cylinder and concave, as tested, results in higher kernel damage than the picker-sheller and in this respect is just as sensitive to high moisture.

It seems that this is an area for some intensive study with other cylinder and concave designs. High-speed moving pictures reveal that the first concave bar seriously interferes with the movement of the ears into the cylinder. Studies will be made with rasp and other types of concave bars in an attempt to remedy this situation and to reduce the amount of kernel damage.

Force Studies. As indicated earlier, for the studies of the forces on the concave, plants were fed in groups of three, spaced to represent normal feeding of checkrowed corn. Some "slug" tests were made by dumping ten stalks onto the feed table in one pile. However, the cylinder appeared to meter its feeding so effectively that the "slug" forces were smaller than those with regular feeding. These tests in 1952 were all made on the cylinder with filler plates.

DETERMINING FORCES ON CONCAVE

Baled straw and soybean hay were used in an attempt to get some idea of the forces on the concave when combining small grains and beans. The oat straw was too dry to give any results, but the soybean hay provided sufficient load to slug the cylinder down and throw the drive belt, as happened in two or three cases with corn. Peak forces on the concave were somewhat lower than those for corn — about 323 lb compared to about 400 lb. However, it will be necessary to run these tests with soybeans fresh from the field to form an accurate comparison.

Fig. 12 shows the effect of cylinder speed on the forces on the concave. The larger forces appear to occur at lower speeds, although speed does not greatly affect the severity of the forces on the concave. Note that average peak and maximum peak forces are shown. The averages are from three or more tests in which from four to six peak forces were measured.

The effect of concave clearance on peak forces is shown in Fig. 13. As would be expected, the forces fall off as the opening is increased, so it is to our interest to use the largest possible opening consistent with satisfactory shelling.

Unfortunately the equipment for measuring forces was not available in time to study the effects of kernel moisture on shelling forces. However, comparisons at 14 and 18 percent moisture were made and are shown in Fig. 14. It will be noted that at these low-moisture levels there is no appreciable difference in the forces.

CONCLUSIONS

1 Both shelling and force measurements indicate that the combine could conceivably harvest corn and with a high degree of efficiency.

2 To get best results, it is necessary to double the number of cylinder bars or add filler plates between the regular bars.

3 The number of concave bars should be kept to a minimum consistent with good shelling in order to provide the least possible hindrance to passage of the cornstalks.

4 Optimum cylinder speed will probably fall between 600 and 800 rpm (2360 and 3140 fpm peripheral speed).

5 The concave-to-cylinder clearance at the front should be from ⅛ to ½ in greater than at the rear.

6 A clearance between ½ and ¾ in at the rear of the concave apears to give best results. Cobs are seldom broken, power consumption is low and shelling is most efficient.

7 The percentage of unshelled corn with optimum adjustment depends upon cob and kernel moisture. A spongy cob splits easily, and then shelling is difficult. Spray application of chemicals to speed up drying of the corn plant promises to be a considerable help.

8 The percentage of unshelled corn compares favorably with that of the picker-sheller.

9 Damage to the corn kernels is higher with the combine than the picker-sheller, but with best adjustments at moisture levels of 22 percent and below, cracked and damaged kernels should fall within the allowance for No. 2 corn. Further study on cylinder and concave design is essential.

10 The maximum forces on the concave appear to be only slightly higher when harvesting corn than when harvesting small grains. However, each group of ears causes forces higher than the steadier loads in threshing small grains. For this reason some strengthening of the cylinder and concave with their mountings will probably be necessary.

11 As expected, forces on the concave diminish as the clearance is increased.

This work has opened up many lines for future study in shelling, and of course this will include correlation of these laboratory results with actual combining in the field. It is felt that these results justify intensive experiments in the next problem of getting the corn into the machine.

Consumptive Use of Water

(Continued from page 460)

GENERAL CONCLUSIONS

Consumptive use computed by the Blaney-Criddle method checks very closely the measured amount of water necessary to produce an average yield of native hay in the Pinedale area of Wyoming.

Using the Lowry-Johnson method, an annual consumptive-use value of approximately twice the measured seasonal use was obtained.

The amount of water necessary to produce a given yield in the Pinedale area is not directly proportional to the yield. As shown in Fig. 3, the relationship appears to be logarithmic. Over the water use range studied, each additional inch of water used gave progressively larger increases in hay yield.

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Strength and Trends of Bolted Assemblies

John S. Davey

BOLTED assemblies are performing better every day, because engineers are becoming more interested in the selection of bolts. Too often in the past, fasteners were considered commonplace and were specified as a matter of course or from rule of thumb. Now they are being given some thought.

What are the steps to take in selecting a fastener? First, determine the load conditions and the amount of stress that it will have to stand. Second, determine whether or not the joint is a rigid one. Then decide whether it is more important to have the bolt in straight tension or to have it overcome shear. Next comes the selection of the grade of bolt, diameter, and number to be used. The style is more or less dictated by the character of the machine.

The load may be either the pull of a tractor, the force of an engine, the weight of a moving load, or the pressure of a fluid or gas. This force is transmitted from part to part and must be carried by the fasteners. The joints between these parts are usually rigid in nature or may be considered so. While no metal is incompressible, in materials having a modulus of 15 million or over it affects the bolt so slightly that for practical purposes it may be neglected. When the joint is rigid, the bolt should have a capacity slightly greater than the calculated load.

If the joint is not rigid, as in the case of gasket joints or pliable materials, the bolt must be capable of withstanding the load of keeping the joint tight plus any applied load. If it is cyclic in nature, the load limit must be within the endurance limit of the bolt. These loads are direct pulls or tension loads.

It is often believed that to overcome shear loads the bolt must fill the hole. This is not correct. To design a bolted joint for shear, the bolt should be stressed in tension to resist the motion of the parts. This would prevent the bolt from coming into bearing. In other words, clamping the parts firmly enough prevents slippage and application of shear loads on the bolt. If parts do come into bearing, forces will be built up that will cause failure of the joint. Because of these forces, design should avoid bolts in excessive bearing unless shear failure is to be provided as a safety measure.

The principal function of a fastener is to clamp component parts together. The clamping force or tension in the bolt is accomplished by wrenching either the head or the nut. During the wrenching operation, the bolt is subjected to several stresses probably more severe than it will ever get again. There is torsion caused by the drag of the nut and bolt threads. There is tension also, and because it is almost impossible to get two bearing surfaces parallel, there is bending. This makes up a combined stress which will cause failure of the bolt before it reaches its ultimate breaking value measured under static tension loads, as measured in a testing machine. A bolt must have some ductility in order to adjust itself to the load-carrying conditions without fracture. Once the wrench is removed and the bolt has adjusted itself, the only load it will have to withstand is straight tension, if it is properly tightened. Fortunately, the stresses produced while torquing up do not cause any harm, providing they are released before the bolt is stressed too much beyond its yield strength for rigid joints and load limit for compressible joints.

The term "properly tightened" expresses the secret of satisfactory joints. Bolts must be properly prestressed to insure satisfactory joints, to resist failure and to stay tight. In the case of rigid materials, the external loads do not seriously affect the bolt load, providing they are not in excess of the initial load on the bolt. Fig. 1 shows how these loads react. The forces T are acting to separate the two pieces of steel. These are overcome by the tension force P in the bolt. Providing P is greater than T there is no chance of the joint separating, and the loads do not affect the bolt load. If, on the other hand, the bolt was not sufficiently tightened, so that T exceeded P, a load would have to be added to P, and the sum might exceed the tensile strength of the bolt. Suppose the load T were cyclic in nature. If the bolt tension P were in excess of T, again there would be little effect on the bolt and the life of the bolt would be indefinite. If T was larger than P, then the bolt would be subjected to varying loads and would have to have an endurance limit capable of withstanding this condition.

A non-rigid gasket joint is shown in Fig. 2, and in this

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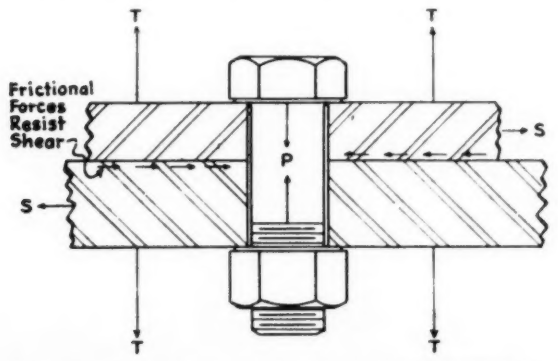

Fig. 1 This drawing shows the forces acting on a bolted connection

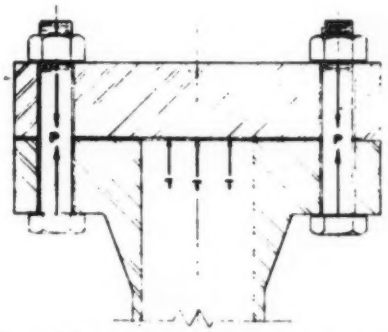

Fig. 2 This sketch shows a non-rigid gasket joint

case the interjection of a soft compressible material changes the picture completely. If there is an external load, usually from pressure within, the force T must be added to the tension P to determine bolt load. This might be the condition found in a steam chest, for instance, where the bolt must be strong enough to withstand the tension P which maintains gasket compression as well as the force T which is the operating force. Often this load will fluctuate, but unless the fluctuation is rapid, it will not cause fatigue failure.

It is quite apparent that in both cases care should be exercised in wrenching up. In the first case the bolt should be prestressed to its yield strength, while in the second it should only be tightened sufficiently to prevent leakage. The balance of strength should be used to overcome added loads.

Proper tightening is so important that it cannot be overlooked. In rigid joints, if the preload is greater than the applied load, the fatigue life of the bolt will become infinite. Preloading is beneficial in providing the necessary bolt loading to prevent unscrewing or loosening. Excessive amplitude of stress change in a bolt has a tendency to cause the nut to loosen. The only way to keep a nut on a bolt, if the materials are rigid, is by proper tightening.

This preload must be maintained throughout the life of the joint. Several things can dissipate this load, such as poor quality surfaces, burrs, rough casting surfaces, paint, foreign matter, brinelling, crushing, or anything which tends to shorten the grip length between the head of the bolt and the nut.

We have seen more joints become loose or fail because of careless wrenching than any other single factor. About 90 percent of the torque effort in tightening a nut is used to overcome friction (Table 1). This friction factor is so easily changed that it is hard to predict just how much torque is necessary to tighten up a bolt. It is known that the torque coefficient times the nominal diameter times the bolt tension gives the torque necessary, and it has been determined that under normal conditions the coefficient is 0.2 which provides an easy empirical formula of torque in inch-pounds as equal to 0.2 times bolt diameter times bolt load. But what are normal conditions? One way to find out is to set up a pilot assembly duplicating the conditions of the joint and try it out. It is easy to determine how much torque breaks the bolt and set a tightening torque of, say, 70 percent of that.

Mechanical or power wrenches properly handled are very satisfactory and should be used whenever possible. If they have throwout clutches these should be watched and checked frequently. If they are of the impact type, they should be of the proper size and the operator should be skilled. We have observed some wonderful results from all these wrenches, but they must be properly maintained and used. It is worth the trouble and expense in implement performance.

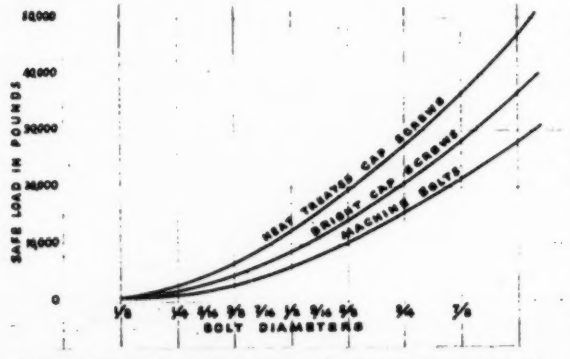

Fig. 3 Comparative holding power of heat-treated and non-heat-treated fasteners

In the selection of grade of bolts, it is suggested that the engineer rely on up-to-date handbooks or manuals. The American Society of Testing Materials has established several grades for bolts which are standard and commonly used. The Society of Automotive Engineers has done the same. These grades satisfy practically all requirements and make it impracticable to specify special non-standard items.

Common fasteners are made of low-carbon steel, usually SAE 1018. Such steels do not react to heat-treatment and, therefore, can be classed as having approximately 55,000 psi tensile strength. Some are in excess of this because of various degrees of cold working, but unless details of strength and load are accurately known, a higher figure cannot safely be used as a basis for design (Table 2).

The next grade is the 1038 heat-treated product. The properties are covered by ASTM 325 and SAE grade 5. We think of it as having 125,000 psi tensile strength, but the sizes above ⅞ in are slightly below this figure. This is becoming the popular grade of fastener. As yet it is made as a stock item only in hex-head capscrews, but it is being ordered as specials in other types of bolts.

There are some bolts being produced from alloy steels to tensile strengths of 150,000 psi, covered by SAE grade 7 and 8. They are expensive products, and unless there is some very special engineering reason to offset the cost, they should not be specified.

The common grade of bolt gives the most pieces per dollar. Where the problem is to fill holes on cover plates, this grade is appropriate. It is a good product and readily available in a variety of sizes and types.

In terms of tensile strength more value per dollar is provided in the 1038 grade. It is a very satisfactory fastener because it has been heat-treated and the properties are controlled. There is really no intermediate between these two grades, although as stated some particular screw may show

TABLE 1. TORQUE COEFFICIENTS

Bolt size	Theoretical*	Torque coefficients—R Measured (average) High-point torque	Mid-point torque
¼–20	0.210	0.243	0.267
¼–28	0.205	0.216	0.231
5/16–18	0.210	0.206	0.186
5/16–24	0.205	0.194	0.183
⅜–16	0.204	0.200	0.247
⅜–24	0.198	0.192	0.234
7/16–14	0.205	0.217	0.224
7/16–20	0.200	0.194	0.190
½–13	0.201	0.205	0.158
½–20	0.195	0.167	0.205
9/16–12	0.198	0.194	0.214
9/16–18	0.193	0.196	0.207
⅝–11	0.199	0.178	0.196
⅝–18	0.193	0.183	0.175
¾–10	0.194	0.169	0.172
¾–16	0.189	0.170	0.180
⅞–9	0.194	0.181	0.194
⅞–14	0.189	0.171	0.178
1–8	0.193	0.188	0.204
1–14	0.188	0.161	0.167
Average	0.198	0.191	0.201

*Computed with coefficient of friction of 0.15 and the dimensions of American Standard regular nuts.

TABLE 2. MINIMUM TENSILE STRENGTH AND MINIMUM BREAKING LOAD OF THREE TYPES OF FASTENERS

Diam., in	Machine bolt ASTM Spec. A-307		Bright capscrews		Hi-carb heat-treated capscrews ASTM Spec. A-325	
	Minimum tensile strength, psi	Minimum breaking load, lbs (coarse thread)	Minimum tensile strength, psi	Minimum breaking load, lbs (coarse thread)	Minimum tensile strength, psi	Minimum breaking load, lbs (coarse thread)
1/4	55,000	1,740	68,000	2,155	125,000	3,960
5/16	"	2,870	"	3,550	"	6,525
3/8	"	4,250	"	5,255	"	9,660
7/16	"	5,830	"	7,210	"	13,250
1/2	"	7,290	"	9,630	"	17,700
9/16			64,000	11,620	120,000	21,790
5/8	"	12,410	"	14,440	"	27,070
3/4	"	18,370	"	21,380	"	40,080
7/8	"	25,370	"	29,500	110,000	50,730
1	"	33,280	"	38,700	"	66,560

up better in a tension test because of cold working. This grade is worth its cost only if the bolt is going to be properly tightened. There is no need of buying holding power if it is not going to be properly used.

One exception to this might be worth mentioning, however. There is an insurance in putting in a heat-treated product, especially if the joint is going to be assembled in the field. Soft or non-heat-treated screws are easy to overtorque, whereas the 1038 heat-treated grade can be set up without fear of stretching the bolt. There are also the savings in smaller holes, lighter parts, fewer number of fasteners, and other features which can make this grade economical (see Fig. 3).

I see little use, if any, for specifying grades 7 or 8 unless there is an extreme temperature problem or some unusual circumstances. If it is used, it must be tightened to its yield strength at least. The surface under the head of the bolt will have to be capable of supporting the load. A high-tensile-strength bolt adds nothing to a joint unless its strength is used.

With the grade decided, working values are known, and it is simple to decide the diameter and quantity needed to carry the total load. Such factors as clearance, number of holes and thickness of metal, are guides in this selection. The tendency seems to be toward more smaller bolts, although that can be overdone.

As to style of bolt, standard items are again most economical. Where the demand is sufficient, new requirements will be covered in revised standards, but the demand must be great. Ours is a high production industry producing in quantities far in excess of the needs of any one customer. The economy is in producing for many and not for a few.

Threads greatly affect the strength and cost of fasteners. There seems to be very little excuse for more than one thread series. After all, the thread is only a means of reducing the distance between the head and the nut in order to set up a clamping force. While it might be possible to design a new series based on what we know today, it is doubtful that it would be worth it. Let us take the two we have, select the better one and use it.

In a comparison of coarse and fine threads on an assembly of a bolt and a nut made up to the same physical properties and dimensions, the bolt with coarse threads will carry greater loads. This is true even though the fine thread has a greater stress area, because the fine threads do not have enough flank engagement and will shear before the bolt has reached its strength.

One user designed a bolt for a special application from alloy steel and heat-treated it to 165,000 psi. The bolt had a fine thread. It was soon proved that it wouldn't carry much load with the ordinary nut, so a thicker nut was used and finally heat-treated. It so happens that a 1038 heat-treated bolt with coarse threads and an ordinary nut will outperform this very expensive combination of bolt and nut, simply because of the thread. I have seen many critical fastener problems cured eventually by changing from a fine to a coarse thread, although the intermediate steps were alloy steel, heat-treated, special nuts and all the trimmings.

Fig. 4 shows results of a test made at the Massachusetts Institute of Technology in some research work on stress distribution. It will be noticed that the stress varies in a coarse-thread nut from 53 percent of the average at the top to 153 percent at the base, while with fine threads it varies 37 percent of the average at the top to 231 percent at the base. This study proved that bolts with fine threads used in steel nuts loaded statically failed at stresses far under the tensile strength of the bolting material, while coarse threads did not. This condition is brought about by more threads in engagement, indicating that extra thick nuts are not the answer.

This also shows that the first thread of a nut carries a proportionally higher load concentration in fine threads, thus precipitating progressive failure of succeeding threads at lower than expected loads. This occurs to an even greater degree when either internal or external thread materials are hard or brittle. This is why coarse threads are specified in cast iron. High non-uniform load also explains why fine threads are not used in soft metals such as aluminum, copper or brass.

When a nut is loaded, it tends to expand because of the wedging action of the thread. *(Continued on page 471)*

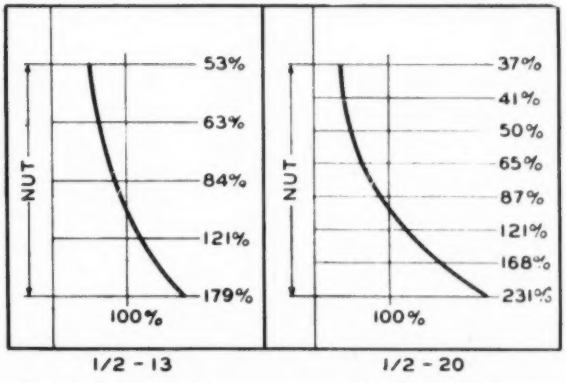

Fig. 4 Stress distribution in coarse-thread vs. fine-thread nuts

Availability and Adaptability of Fasteners

Fred C. Ewert
MEMBER ASAE

IT HAS been said that the farm equipment industry is the leader in the use of fasteners, not tonnagewise but in the types and sizes of fasteners. In this discussion, an attempt will be made to cover recent developments, the work accomplished by various standardizing bodies, how this work affects agricultural engineers, and mention of fastener trends in the farm equipment industry.

Specialties. There has been a considerable increase in the proportion of specialty products as demands for stronger and safer implements are reflected in the need for stronger and better fasteners to hold them together. Some of them can be mentioned without becoming specific on trade names.

There are three basic types of washers—plain, anti-turn and spring. There is also the combination spring and anti-turn type which has the advantages of both types, in that continued pressure is exerted on the threads and sharp tangs or teeth impinge on the work surface to prevent turning.

All of these types of washers are made available with screws as permanently assembled units. This is done by slipping the washer onto the screw blank before it is rolled. The threads hold the washer on the screw, but it is free to rotate and seat properly when the screw is tightened down. Some advantages claimed for these combination washer and screw assemblies are that they reduce assembly costs and time, eliminate awkward assembly problems, save screws and washers wasted in assembly and insure use of the correct washer.

A similar specialty goes a step further, leaves off the washer, but instead places a series of serrations under the head to serve as an anti-turn bearing surface. The entire part is casehardened a few thousandths of an inch. These file-hard teeth bite into the work surface and thus prevent turning and subsequent loosening. A recent development is an assembly consisting of the nut and a washer; the washer is staked to the nut, making it one unit.

Another specialty has found favor because it provides an elastic yield without reduction of shank diameter. This is a hexagon-head bolt. The head is formed with a cuplike depression in its upper face and a circular recess adjacent to the shank in its underface. With this bolt, greater elastic stretch can occur than in a standard bolt equally loaded. It stays tight when a standard bolt will loosen.

There have been some new advances in studs. While ordinary means of mounting studs require drilling, tapping and tightening, other ways have been introduced, such as electrically welding them to a metal surface or pushing them into the surface by means of a powerful powder charge.

Rivets, a standby in our industry for years, and still one of the simplest and most economical fastening devices, are usually classified as solid, split, tubular or blind. Where it is impossible to reach both sides of the work, blind rivets in a variety of sizes, types and styles are used. They are set from one side only. The setting operation can be performed by the mandrel-like action of a plug pulled entirely through the rivet body; by a plug pulled partially through and then severed; by a squeezing action that results from an internally threaded portion of the rivet body being drawn up behind the joined sheets, or by a flaring action that results from an explosive charge in the shank of the rivet proper.

Stapling and stitching various metallic and non-metallic materials constitutes one of the most rapid and versatile fastening techniques. This method of fabrication requires no punching or drilling of holes, no precleaning operations, no heating or cooling time, and no assembling or tightening operations. Stitching is the term used to denote the fastening operation where a length of wire is cut from a coil and formed into the fastener as each stitch is made, while stapling employs preformed fasteners. The finished job looks the same in both cases.

There are an amazing number of specialty devices in the field of light metal fastenings, since light metal isn't thick enough to provide strength in a tapped hole. Representative are tapping screws in drilled, punched or extruded holes. Some are of the thread-forming design, others are for thread cutting. Various makes of cage nuts, plug nuts, weld nuts and nut retainers are on the market, but they all have one purpose in common — to provide for blind assembly and for long thread engagement.

Drive pins of various types are available, generally heat-treated to achieve maximum toughness and shear strength. Compressed as they are driven into a hole, they exert continuous spring pressure against the sides of the hole and prevent loosening by vibration. Hairpin cotters are another specialty for slipping around a shaft or with one leg through a drilled hole in the shaft and are easily removed.

Locknuts. Many strange designs, some good and some bad, have been devised for locking nuts on bolts, since the first patent was issued on them in 1854. Early locknuts were usually so impractical from a cost and production standpoint that little attempt was made to introduce them. The last few years have seen a great change and locknuts of many designs find many different types of applications. Probably the biggest reason for the considerable interest they have attracted is the extensive use that has been given them on military equipment.

Virtually all locknuts are designed to function on the same general principle — providing a gripping action on the bolt threads to prevent back-off and subsequent loosening. Some types accomplish this by distortion of the entire nut during manufacture, some by distortion of the nut in application through pressure against the work. Some hold the bolt by less than one full thread; others use non-metallic inserts which the bolt must tap as it enters.

A few, in addition to preventing the bolt from turning, provide increased thread pressure in a longitudinal axis to compensate for bolt stretch, or wear of bolted components, thus assuring a tight fastening under most severe conditions.

There is increasing use of locknuts in all industries, even for implements and tractors. Probably no one locknut

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Power and Machinery Division.

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will handle everything such a nut might be expected to do. No good reason may be found for using locknuts at all. Whatever may be the attitude as to the efficiency of locknuts in keeping bolts tight, it is safe to state that if the bolt does come loose, the locknut will hang on and keep the assembly from falling apart.

One thing which makes it hard to evaluate locknuts is lack of suitable testing equipment on which engineers can agree. Some of the most popular laboratory tests are vibration tests and installation and removal tests. One of the bolt companies is supposed to be doing some work on a new locknut testing fixture. As of today field testing is still probably the best way to determine which type to use.

Fastener Standards. Not too long ago the bolt salesman had to satisfy only the purchasing agent. Now his product must meet rigid standards and satisfy quality control, engineering, inspection, and production. This greater interest in the requirements has been reflected in standards work which is being carried out on a national basis.

SAE Standards. The Society of Automotive Engineers has done a remarkable job in getting together producers and consumers and obtaining agreement on several classes of bolts with definite physical requirements. So long as most of us were using the low-carbon carriage and machine bolts, there wasn't too much attention paid to physical requirements. But with more exact engineering and demand for higher quality fasteners, suppliers were swamped with a lot of queer specifications which meant custom work on practically every batch of high-strength bolts.

For example, one supplier was working to seven different hardness ranges for heat-treated bolts specified to be made of 1035 steel. Dozens of tensile and yield strength ranges were specified, although few of them ever became so exact as to say how the yield strength should be determined. Some specifications even tied down the minimum reduction of area in the threaded portion when tensile tested.

A WORD TO THE IMPLEMENT DESIGNER

The designer of the implement should confine his specifications to essential physical properties and should leave it to the fastener manufacturer to determine how and with what he will produce the required product. SAE provides eight classes of bolts which should take care of most needs.

There are improvements scheduled in these grades for the next revision of the SAE Handbook, and in the future more designers will likely pick their fasteners from this standard. Probably three or four will suffice in most farm equipment work. Our company does pretty well with four grades: grade 1 for commercial carriage and plow bolts, grade 2 for commercial capscrews and machine bolts, grade 5 for all types of high-strength carbon steel bolts, and grade 8 for occasional use of high-strength alloy bolts. If all companies made all of their own bolts, controlling wire properties and heat-treatment, they could boost their carriage and plow bolts into grade 2. It can't be done otherwise without increasing costs.

American Standards Association Work. Dimensions of fasteners have undergone changes in the past two or three years and these have found their way into American Standards. Standards cannot be regarded as permanent or static; if the product is to improve, there are bound to be changes. A lot of them have affected our industry. For example, a two-year effort by a committee of users and producers succeeded in reducing the scores of head variations and body styles of plow bolts to two head types — the No. 3 with 80-deg round countersunk head, square neck, and the No. 7 with 60-deg round countersunk head, reverse key. Also shown in the standard and intended for repair work only are the No. 4 countersunk square head and the No. 6 heavy key round countersunk head.

All special plow bolts will never be eliminated, but this revised standard, by recognizing the No. 3 and No. 7 head types as overwhelming favorites, should go a long way toward accomplishing its aims of more usable inventories, better interchangeability and cost reduction.

Plow bolt standards may require further revision as better countersinking methods may demand another look at head dimensions. Accuracy of holes will have to be matched by accuracy of fasteners.

Another item that has been recently added to the American Standards is the short square neck carriage bolt. This was developed because of usage in the implement industry and since it was a development within our industry, it will be explained a little later.

PLOW BOLTS ORIGINALLY FOR PLOWS

As the name implies, plow bolts were originally for plows, but are used now in any application where there is a need for bolts to fit flush and still not turn in the hole. The American Standards Association is trying to get away from the old type names and adopt more apt names.

For example, the regular carriage bolt is now the "round head square neck bolt" and the new carriage bolt that was just mentioned is now the "round head short square neck bolt". The man who sells them and the man who uses them will go on calling them carriage bolts.

Unified threads are now an accomplished fact. There isn't too much difference between the new standard and the old one. The big reason for the revision was to provide interchangeability of screw-thread products with England and Canada. The unified thread leaves a minimum clearance on the class 2 thread to prevent tight fits during wrenching and consequent seizure. The unified thread is more realistic since it recognizes the need for more tolerance on the nut than on the bolt. The fastener strength is not affected, nor is the fastener assembly affected.

When first published, suppliers doubted that they would be changed over to the new standards before several years had passed. However, the changeover was accomplished in a surprisingly short time by most of them. There is still a transition period during which threads to the old and new standards will both be available. The new thread will in no way obsolete present fastener stocks. It is quite essential in this transition period that inspection be for usability rather than for the least little irregularity in dimension.

The B18.2 standards on square and hexagon bolts have been revised. Heretofore limited to certain general head proportions, the new standard not only shows standard head proportions but body diameters and tolerances, thread pitch and class, thread length, pointing and recommended materials.

In addition to developing more complete product standards, special attention was given to similiarity of existing standards and some major changes resulted. Most important

of these was widths across flats. Now capscrews and hexagon head bolts have the same head dimensions. This was accomplished by using the former across-flat dimensions of the capscrew for sizes up to ⅝ in diameter and by using the former across-flat dimensions of the regular hexagon bolt for sizes ⅝ in diameter and larger. Head heights were also standardized. The head height of the new standard is based on a ratio of ⅝ of the nominal diameter of the bolt.

Across-flat dimensions of hexagon nuts now agree with those of the bolt except for minor deviations in the 7/16 and 9/16 in sizes. This was accomplished by using the former across-flat dimensions of the light series for sizes up to and including ⅝ in and the former across-flat dimensions of the regular series nut for sizes above ⅝ in.

The changes referred to above are summarized in published American Standards.

Some definite advantages which have resulted from the new standard are as follows:

1 Complete specification of characteristics that previously varied with trade practice and individual specifications

2 Establishment of definite thread lengths for the various bolts and screws

3 Elimination of unnecessary differences between hexagon capscrews, automotive bolts, and regular bolts, as well as between light and regular nuts

4 Simplification of wrench equipment.

5 Conservation of material

6 Unification for defense purposes.

CONSIDERATIONS IN USE OF BOLTS AND NUTS

Some considerations entering into the use of bolts and nuts made to these standards will be of special interest. One concerns the increased width across flats of capscrews in diameters of ⅝ in and larger. The dimensions are now the same as those for machine bolts. In using capscrews for assembly in close quarters, such as next to a flange, the new head may not fit. For example, width across flats of the old ⅝ in capscrew was 1 in, while the new width is 1⅛ in. There shouldn't be many such applications, but where they exist, mixed stocks should be avoided. New design, of course, will allow for the larger head.

What hexagon bolts should be specified? The new standard covers four — the regular hexagon bolt, the regular semi-finished hexagon bolt, the finished hexagon bolt, and the hexagon head capscrew. The finished hexagon bolts and capscrews are identical. Both are included because some people wanted to call them bolts and others wanted to call them capscrews. Some think two of these classes are enough — the regular hexagon bolt and the capscrew. The capscrew would be washer-faced or chamfered while the hexagon bolt would not.

A point on the use of the regular hexagon bolt is that ASA has not been realistic on the body diameter tolerances they show. For example, consider a ⅝ in diameter regular hexagon bolt. The maximum body diameter is shown as 0.675 in, which is 0.050 in over the nominal. Where practice is to drill holes 1/32 in larger than the fastener diameter, a bolt to the maximum tolerance would cause trouble. Closer body tolerances are to be expected on cold-headed bolts than on those which are made hot. However, even in the cold-heading range, the ASA standard shows body tolerances which might give trouble, depending on hole size practice.

For diameters through ½ in there is a plus tolerance of 0.030 in, for diameters ⅝ and ⅞ in, the plus tolerance is 0.050 in, and over ⅞ through 1¼ in diameter, the tolerance is 0.063 in. Attempts have been made to get these tolerances revised, but without success as yet.

The last point which might give concern is hexagon nuts. The finished hexagon nut has been designed to the new Unified standard, and it is hoped eventually to swing all of industry to this standard. For an interim period, however, manufacturers will continue to make regular hexagon nuts which are not to the unified dimensions. For sizes 5/16 through ⅝ in the widths across flats will be 1/16 in greater than specified for the Unified series. Stock mix-ups could result.

If there could be assurance that, as of a certain date, all fasteners would be to the new standards, it might help, but it is believed that suppliers will be entangled in the change-over for quite some time. A recent canvass of several suppliers indicated that there was a wide variation in the progress being made. It would be to the benefit of both producers and consumers to keep the change-over period as short as possible.

FEI Committee on Fasteners. Due to the increasing interest being shown in fasteners by the farm equipment industry, a committee on fasteners was organized in November, 1949, under the jurisdiction of the Farm Equipment Institute. It consists of representatives from various farm machinery manufacturers, and its primary purpose was to provide the farm equipment industry with a means of standardizing its fastener items not covered by existing standards.

The first project undertaken by the committee was the establishment of an industry standard for a short square carriage bolt. The proposed standard was to replace the many varieties which had resulted from the engineer's search for a more adaptable bolt.

AMERICAN STANDARD CARRIAGE BOLT

The regular carriage bolt, with its longer depth of square, was designed for wood sections and the proposed short square had to be suitable for most applications in thin metal sections without interference of the square under the head.

This standard was published and has been adopted as an American Standard. It is receiving wide acceptance in our industry as well as others. Another advantage in addition to those for which the bolt was designed is that the short square makes it easier to cold head in medium carbon steel.

A second project of this committee has been the establishment of a standard to cover headed, drilled pins. A survey of the industry indicated great variations of head types, hole sizes and distances of hole from end of the pin.

The committee's object was to promote a pin which would be economical to produce and which in time would have a reasonable chance of being stocked. Therefore, one type of head was selected, hole size was standardized for each diameter of pin, and distance from under the head to center of the hole was standardized for each length.

This headed drilled pin has been published as an ASAE Standard. Since the use of such a pin is confined to the implement industry, there doesn't appear to be any reason for including it in the American Standards.

Some of the ways in which the new ASA revisions might cause annoyance have been indicated and it should be to our advantage to be able to present the views of the farm equipment industry to those organizations which are most responsible for these standards. As an industry, we have never taken a serious part in the work of the American Standards Association and consequently seldom learned of important changes until after the revised standards were published. Through the FEI fasteners committee, we can be kept up to date on what is being contemplated, since many of its members are on ASA committees dealing with plow bolts, carriage bolts, washers, hexagon bolts, and the like.

The farm equipment industry should continue to maintain its interest in standardization, not only because it helps engineers to keep informed of current trends, but because it also makes it possible to make our influence felt in standards activities.

Trends in Fasteners for Farm Implements. I spent a few days at two state fairs, visiting all the implement exhibits and comparing the types of fasteners used for similar locations in similar machines and came up with the conclusion that there was very little that was similar. However, a general pattern was indicated as to where the industry was heading on the use of fasteners.

Formerly the most common fastener was the square-head machine bolt with square nut. This was the all-purpose bolt assembly, but now there is a definite trend towards hexagon-head bolts and hexagon nuts. One trend is the use of fasteners for sheet metal parts which provide easier and more economical assembly. Mentioned earlier were tapping screws and various types of nuts. One popular spring type of nut engages but one bolt thread.

FINE-THREAD BOLTS INCREASING IN USE

There is an increasing use of fine-thread bolts. In his paper published elsewhere in this issue, John S. Davey gives convincing reasons for sticking with the coarse-thread series, and they sound sensible. Nevertheless our industry is taking up a trend which is losing ground in other industries and some data should be collected on the two-thread series. Some thought is being given to a research program, to be conducted at some university and sponsored by industry, including farm equipment, to determine, once and for all, the relative worth of fine threads and coarse threads.

A rather revolutionary trend is the increasing use of medium-carbon high-strength bolts such as are covered by SAE grade 5 and ASTM A-325. Designing to yield strength, these are more than twice as strong as the low-carbon bolts covered by SAE grades 1 and 2. Despite this increased strength of the bolt, there is no reason to go to a stronger nut. A conventional low-carbon nut, either cold punched or cold forged, should be satisfactory.

Another trend in farm implements is the increasing use of plated fasteners. These are especially desirable where the farmer has to disassemble frequently. You all know the trouble with rusted bolts and nuts, especially with some of the "knuckle-buster" wrenches. Another point observed on plated fasteners was that smaller companies made more use of them proportionately than did the larger companies.

As a closing thought, farming is an exacting business, and with farms so highly mechanized it is necessary that the implement maker use great care in the selection and application of fasteners. The number of items has increased innumerable times, both in sizes and types, as a result of the increasing use of farm machinery and the broad diversification of heavier farm machinery.

This places a burden on dealers and hardware stores, and a little thought by the designer will help materially in weeding out large inventories of special sizes.

In the considerable literature which has been made available to engineers on the subject of fasteners, one of the best sources for information is the magazine issued quarterly by the Industrial Fasteners Institute, available on request.

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4 Strength and Trends of Bolted Assemblies, John S. Davey, AGRICULTURAL ENGINEERING, 1953.

5 Square and Hexagon Bolt Standards, H. W. Robb, *Fasteners*, vol. 8, no. 3.

Bolted Assemblies

(Continued from page 467)

markedly at the nut base and because of the greater load concentration, is more pronounced in fine-thread nuts. This expansion results in recession of the nut radially with respect to the bolt threads, producing thread contact at thinner sections of the thread, thus precipitating stripping. The expansion has less effect in reducing stripping strength of coarse threads because of the greater thread depth.

We have all heard that fine-thread bolts will not loosen in service. This is false; in fact, the threads have nothing to do with it, because if the joint is properly designed and the bolt tightened to the proper tension, neither one should loosen. Surely the recent research work in the use of high-strength bolts in structures such as railway bridges are ore unloaders, which are subjected to severe shock and vibration, prove that coarse-thread bolts will not loosen. In the many full-scale laboratory tests and field installations using coarse threads, there has not been a single case of nut loosening where the above principles have been employed, although no locking devices of any kind have been used.

Decarburization is sometimes present at and below the surface of threads and is difficult and expensive to avoid. A given amount of decarburization is less effective in reducing the stripping strength of coarse threads, because of their greater thread depth.

Corrosion is likewise less damaging to coarse threads. This is important in equipment and machinery subject to constant outdoor exposure. Protective coatings can be employed more effectively and heavy coating, such as hot galvanizing, is only practical on threads with pitches coarser than 18.

Coarse threads are less subject to injury in handling. They are far easier to assemble as they require only about two-thirds as many revolutions for any given movement of the nut along the length of the bolt. Bolts and nuts with coarse threads are much easier to start without crossing threads. This is especially important with bolts located in inaccessible places or assemblies done in the field or under adverse conditions. Coarse threads are less apt to gall or seize in high-cycle assemblies.

PROPOSED ASAE RECOMMENDATION:

Design and Construction of Tile Drains in Humid Areas

EDITOR'S NOTE: This proposed ASAE recommendation is being published to give ASAE members an opportunity to review and comment on it before it is presented to the Council for approval as an official recommendation of the Society.

This ASAE Recommendation was prepared as a guide to engineers in the design and construction of tile drains, particularly as a basis for writing detailed specifications for a particular job. However, the Recommendation is not designed to serve as a complete set of specifications or standards. *They are not applicable to drainage of irrigated lands.*

This Recommendation is a contribution of the Subcommittee on Design and Construction of Tile Drains, Committee on Drainage, Soil and Water Division, American Society of Agricultural Engineers—K. H. Beauchamp (chairman), W. A. Cutler, E. W. Gain, K. W. Hotchkiss, C. L. Larson, J. H. Lillard, Virgil Overholt, H. F. Peckworth, G. O. Schwab, F. F. Shafer, and Phelps Walker.

SECTION I. DRAINTILE

1 *Quality*

All tile installed should meet the requirements of the American Society for Testing Materials (ASTM). The ASTM specifications are subject to revision from time to time. (Currently those for draintile are covered by the Tentative Specifications for Draintile, ASTM Designation C4-507.) Copies of the specifications may be secured from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

(a) Standard draintile may be used for ordinary conditions of exposure and where the tile are laid in trenches of moderate depth.

(b) Extra quality draintile should be specified for unusual conditions of exposure, or where the tile are laid in trenches of considerable depth or width, or both.

(c) Concrete tile should not be removed from the manufacturing plant until properly cured. It is not good practice to install concrete draintile within 30 days of manufacture. Clay tile are ready for installation as soon as they have been removed from the kiln.

(d) Where tile will not be subject to freezing and thawing, the ASTM freezing and thawing and the absorption test requirements may be modified by the purchaser.

2 *Tile Exposed to Harmful Soil Conditions*

(a) Soil Acids. Soil acids affect all concrete tile to a varying degree. Acid soil solutions attack cement mortars and concretes by dissolving some of the cement constituents. Clay tile are not affected. The degree of acidity of soil is commonly expressed by pH values. A pH value of 7.0 is neutral. When the pH number is greater than 7.0, the soil is basic. Conversely, when the pH number is less than 7.0, the soil is acid, and the smaller the number, the greater the acidity. [Caution: Hydrogen ion determinations, while ordinarily reasonably reliable, are not infallible as some soils with pH values higher than 7.0 may become acid by exchanging a hydrogen ion for a base ion in reaction with a salt solution.]

Where soils or drainage waters are acid it should be stipulated, even though subject to possible error for the reason stated, that:

(1) Standard quality concrete tile can be used in mineral soils having a pH number of 6 to neutral.

(2) Extra quality concrete tile can be used in mineral soils where the pH varies from 5.5 to neutral.

(3) Extra quality concrete tile can be used in organic soils having a pH number of 6 to neutral. Concrete tile should not be used in organic soils when the pH number is much less than 6.0.

(b) Sulphates. Clay tile are not affected by sulphates. Most concrete tile are so affected to varying degrees*.

Where soils or drainage waters contain appreciable quantities of sodium or magnesium sulphates, the following precautions should be observed if concrete tile are to be used; (the pH of a soil is not necessarily an indicator of sulphates):

(1) Where the combined concentration of sodium and magnesium sulphates is appreciable, but less than 3,000 ppm, concrete draintile shall be of extra quality and shall be made with a sulphate-resistant cement (ASTM Types II, IV or V).

(2) Where the combined concentration of these sulphates is 3,000 ppm or more, concrete draintile shall be extra quality, shall be made with a cement of high sulphate resistance (ASTM Types V or II with less than 5.5 percent (C_3A) and should be cured for suitable time periods in steam at temperatures of 212 F or higher.

3 *Tile Exposed to Freezing and Thawing*

(a) Concrete draintile meeting ASTM specifications are generally frost-resistant and require no special precautions.

(b) Clay tile may be damaged by frost action. In areas where the temperature conditions are particularly severe, clay draintile laid with less than 2.5 ft of earth cover should be of extra quality.

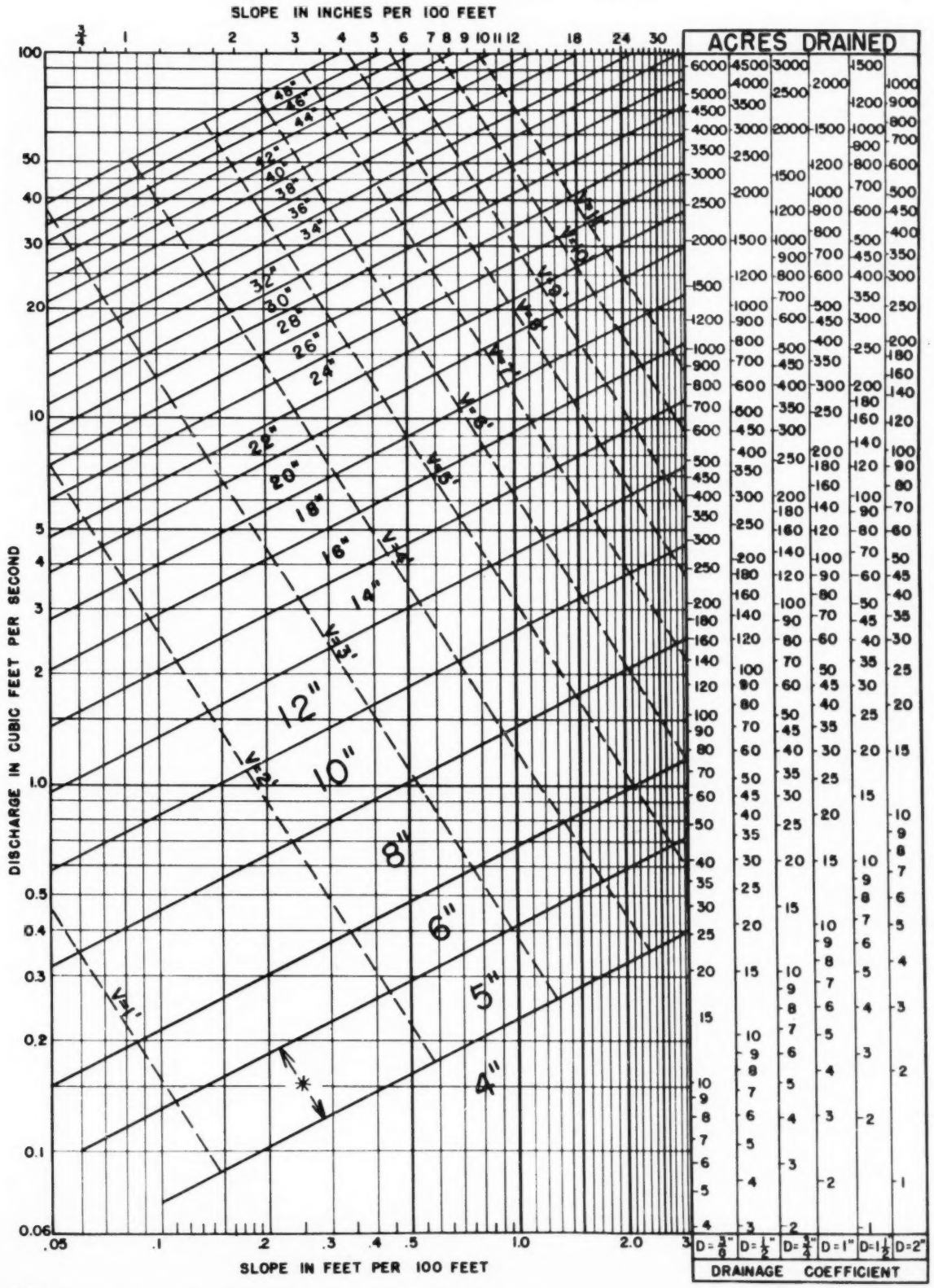
(c) Clay draintile should not be strung out or stacked in contact with the ground or other sources of moisture during the winter or periods of freezing and thawing.

*For more detailed information on the problems of soil sulphates and acid soils with reference to concrete tile refer to the following University of Minnesota bulletins: Technical Bulletin 180, "Durability of Concrete and Mortars in Acid Soils with Particular Reference to Draintile," and Technical Bulletin 194, "Long-Time Tests of Concrete and Mortars Exposed to Sulphate Waters."

Fig. 1 (See opposite page) Tile drainage design chart from Yarnell-Woodward formula, $V = 138 r^{2/3} s^{1/2}$ (USDA Bulletin 854—chart prepared by Michigan State College, 1953.)

HOW TO USE CHART: (1) Find the number of acres to be drained in the selected drainage coefficient column. (2) Project a horizontal line to the left until it intersects the vertical line representing the grade of the tile line shown at the bottom of the chart. (3) The tile size shown in the space between diagonal solid lines where the point of intersection occurs is the required size of tile to use. (4) The diagonal dotted lines show the velocity of flow in the tile. (5) Continue the horizontal line until it intersects the left vertical marginal line to find the discharge in cubic feet per second.

TILE DRAINAGE DESIGN CHART



*Space between lines is the range of tile capacity for the size shown between lines

SECTION II. DESIGN

1 *Capacity and Depth of Outlet Drain*

(a) Open Ditch. Where the outlet is a stream or open ditch, it should provide a free outlet for tile drains within a reasonable period of time after a heavy storm peak flow and should be large enough to remove the surface water runoff from its watershed in time to prevent crop damage by overflow. Accepted drainage runoff data should be used in the design of new outlet ditches or in checking for capacity of existing ditches. The outlet ditch should be deep enough that when the lateral tile are laid at the optimum depth for the soil to be drained, the flow line (tile invert) of the main at the outlet will be at least 1 ft above normal low water flow in the ditch. This clearance should be increased to 18 in if the outlet drain is in sandy or organic soils or is subject to rapid filling with sediment. This clearance may be reduced when the outlet ditch is on such a grade that sedimentation does not occur and when there is very little water flow in the ditch a few hours after a storm.

(b) Existing Tile Main. Where an existing tile main is used as the outlet for a proposed system, the outlet drain should be carefully examined. The tile should be in good condition, free of failures and working properly. It should be deep enough to permit the laterals of the proposed system to be laid at the optimum depth for the soil to be drained. It should have sufficient available capacity based on the area served to handle the proposed system, allowance being made for surface inlets and possible additional tile lines.

(c) Pump Outlet. When the outlet ditch does not provide a suitable gravity outlet for the tile system and it is impractical to improve the ditch, pumping should be considered as a means of providing an outlet.

2 *Drainage Coefficient*

The drainage coefficient is the rate of water removal that must be handled in order to provide the required degree of protection to the crops to be grown. The frequency, intensity and duration of rainfall as well as the porosity and permeability of the soil, and crop to be grown, should be considered in selecting the drainage coefficient within the ranges given.

(a) When the land to be tiled has complete surface drainage provided either by the natural topographical formation of the land or by artificial channels, land smoothing or diversions and no surface water is admitted directly into the tile lines, the following coefficients should be used:

	Coefficient (Inches to be removed in 24 hr)	
Soil	Field crops	Truck crops
Mineral soils	3/8 to 1/2	1/2 to 3/4
Organic soils	1/2 to 3/4	3/4 to 1 1/2

(b) Where it is necessary to admit surface water through surface inlets into the tile system, the following coefficients should be used:

	Coefficient (Inches to be removed in 24 hr)			
	Field crops		Truck crops	
Soil	Blind inlets	Open inlets	Blind inlets	Open inlets
Mineral	1/2 to 3/4	1/2 to 1	3/4 to 1	1 to 1 1/2
Organic	3/4 to 1	1 to 1 1/2	1 1/2 to 2	2 to 4

(c) When high-value truck crops might be damaged by standing in water from 2 to 4 hr during hot weather, a higher coefficient than those given in *(a)* and *(b)* above may be necessary to hold crop damage to a minimum.

(d) When the tile line is to be used for intercepting seepage and springs, adequate field investigations must be made to determine the amount and extent of seepage as well as the watershed area contributing to the seepage problem and the time required for the seepage to reach the tile.

The watershed area, soils, stratification and local experience with similar systems should be considered in determining size of tile to intercept hillside seepage.

When large isolated springs are to be intercepted, the amount of spring flow should be measured.

If the area of interception is substantial and indicates the requirement of a rather large tile size, diversions and terraces to intercept surface flow on the slope should be considered, as well as open-channel diversions near the location where the seepage appears on the surface in order to cut off some of the seepage water.

3 *Capacity of Mains and Laterals*

To provide the required tile capacity based on the selected drainage coefficient, the Yarnell-Woodward formula, $V = 138\, r^{2/3}\, s^{1/2}$ should be used, in which V = mean velocity in feet per second, r = mean hydraulic radius, and s = slope of tile expressed in feet per foot.

To simply the use of this formula the draintile design chart, Fig. 1, can be used. The selected drainage coefficient must be applied to the correct area if the required capacity is to be provided.

(a) Where no surface water is admitted directly to the tile through inlets, the selected drainage coefficient should apply only to the wet land area requiring tile drainage. An exception to this is where the runoff from an upland watershed spreads out over the area to be tile drained, thus adding an additional load over that produced by actual rainfall. If the runoff from this upland watershed cannot be diverted away from or channeled through the area to be drained, the drainage coefficient should be applied to the watershed area, if the permeability of the soil makes this feasible.

(b) When surface water is admitted directly to the tile line through surface inlets, the entire watershed draining to the surface inlet should be used as the contributing area. An exception to this condition is where only a small amount of the runoff will be impounded at the location of the inlet and the remainder will flow away in a confined channel. The tile line should then be designed to carry away the impounded water in 8 to 12 hr depending upon the permeability of the soil, and lateral lines within the impounded area should be placed at about one-half the normal spacing.

4 *Minimum Size of Tile*

For good agricultural drainage in mineral soils extending over a long period of time with low maintenance costs and considering present-day construction methods and probable development in crops and farming practices, the use of a 5-in tile as a minimum size for laterals is recommended by the state colleges of several states.

Under the conditions given, the following limitations should apply to use of

(a) 4-in tile:

(1) Use only in mineral soils containing only small amounts of fine silt and sand

(2) Tile lines on grades of 0.1 percent or more

(3) Tile lines not over 1,300 ft in length.

(b) 5-in tile:

(1) Use for sands or non-cohesive soils

(2) Soils containing frequent sand pockets or layers of sand.

(c) 6-in tile:

(1) Use for tile lines with surface inlets

(2) Peat and muck soils (Tile of 18 to 24-in length recommended).

5 *Minimum Depth*

(a) Mineral Soils. The designer should recognize that most experimental work shows that crop yields increased as tile depths were increased from 24 to 42 in and more. It is therefore desirable for the depth of laterals to average 3 to 4 ft. This may be reduced to 2.5 ft with laterals spaced approximately 3 rods apart under the following conditions:

(1) For slowly permeable soils

(2) Where there is a layer of extremely tight soil, sand or large stones that prohibits greater depth

(3) In depressional or impounded areas

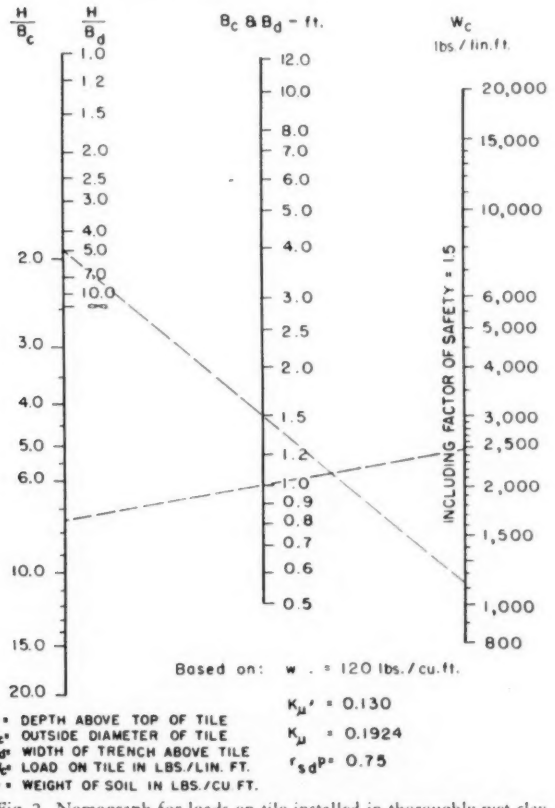

H/Bc
H/Bd
Bc & Bd - ft.
Wc
lbs./lin.ft.
INCLUDING FACTOR OF SAFETY = 1.5
Based on: w = 120 lbs./cu.ft.
Kμ' = 0.130
Kμ = 0.1924
rsd = 0.75
H = DEPTH ABOVE TOP OF TILE
Bc = OUTSIDE DIAMETER OF TILE
Bd = WIDTH OF TRENCH ABOVE TILE
Wc = LOAD ON TILE IN LBS./LIN. FT.
w = WEIGHT OF SOIL IN LBS./CU FT.

Fig. 2 Nomograph for loads on tile installed in thoroughly wet clay (from paper by Schilfgaarde, Frevert and Schlick, AGRICULTURAL ENGINEERING, vol. 32, July, 1951)

(4) Where outletting is a problem

(5) Where cropping conditions require rapid drainage of upper horizons of the soil profile.

The very minimum of cover to protect the tile from breakage by heavy machinery should be 2 ft of soil over the tile.

(b) Organic Soils. Organic soils should not be tiled until after initial subsidence has occurred. To produce initial subsidence, open ditches should be constructed in deep muck and peat land to carry off free water and the area allowed to stand or be partially cultivated for a period of from 3 to 5 years before installing tile. Subsidence will continue after the initial stage and may be as much as 0.1 ft per year due to oxidation under cultivation, compaction, shrinkage and wind erosion. Therefore, the minimum working depth of tile should never be less than 4 ft. Control drainage should always be given consideration. Experimental data show that the subsidence rate increases as the average depth to the water table during the crop season increases. The very minimum of cover to protect the tile in organic soils from breakage by heavy machinery should be 2½ ft of soil over the tile. If control drainage is not provided to hold subsidence to a minimum, this depth of cover should be increased to 3 ft. The economics of clearing and draining organic soils is questionable if depth of muck over an unproductive base material is less than 4 ft.

(c) When it is impossible or uneconomical to secure the minimum cover specified in *(a)* and *(b)* above under waterways and road ditches, at the outlet end of the main or near structures, the draintile should be replaced with metal pipe or other high-strength continuous rigid pipe.

(d) Mains should be laid deep enough so that laterals can be joined at the approximate center of the main tile.

6 *Tile Loading*

(a) Draintile should be so installed that the load does not exceed the required minimum average crushing strength of the tile as set forth in ASTM C4-50T, "Tentative Specifications for Drain Tile" (1950). Minimum crushing strengths are listed for two classes of draintile, namely, standard and extra quality. Loads on draintile should be determined from formulas developed by Marston at Iowa State College. Crushing strengths in the sand-bearing method of ASTM C4-50T are to be used for comparison with the calculated loads as determined by the Marston formulas.

(b) The nomographs shown in Figs. 2 and 3 are based on Marston's formulas and are presented to simplify the computation of loads on draintile for two generally encountered soil conditions, namely, thoroughly wet clay and saturated sand. Soil constants for each condition are shown on the nomographs. The results are applicable for conduits in narrow or wide ditches. The nomographs permit the determination of loads for either ditch conduit or projecting conduit conditions with a minimum of calculations. Projecting conduits are conduits installed in shallow bedding with their tops projecting above the surface of the ground and then covered with an embankment. This condition prevails in unusually wide trenches. The maximum projecting conduit load is assumed to be the maximum loading

possible on a tile laid in a ditch two or three times wider than the outside diameter of the tile. The lower value of the load as obtained from the nomographs is the one to be used in design. The following notation will be used:

D = depth of trench to bottom of tile
H = depth of trench to top of tile
B_c = outside diameter of tile
B_d = width of trench measured at the top of the tile
W_c = load on tile in pounds per linear foot
w = weight of soil in pounds per cubic foot
K = Rankine's constant, defined in terms of μ
μ = coefficient of internal friction of the fill material
μ' = coefficient of friction between fill material and side of ditch
$r_{sd}p$ = ratio depending on the "projection ratio" p and the "settlement-deflection ratio" r_{sd}.

(c) The nomographs can be used to determine the load for a given set of conditions or to determine the maximum allowable depth for tile of specified strength. For example, the load on a 10-in tile installed 8.5 ft deep in an 18-in ditch in thoroughly wet clay can be solved by using Fig. 2 as follows:

Projecting conduit: $\frac{H}{B_c} = \frac{D-B_c}{B_c} = \frac{8.5-1.0}{1.0} = 7.5$

Place straight edge on nomograph on points $H/B_c = 7.5$ and $B_c = 1.0$, and read on right line in Fig. 2, $W_c = 2{,}470$ lb per lin ft.

Ditch conduit: $\frac{H}{B_d} = \frac{D-B_c}{B_d} = \frac{8.5-1.0}{1.5} = 5.0$

Read on right line $W_c = 1{,}130$ lb per lin ft.

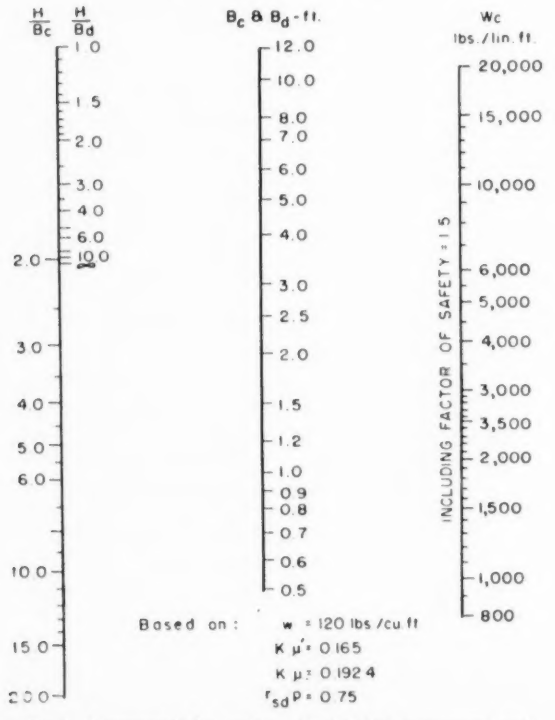


Fig. 3 Nomograph for loads on tile installed in saturated sand (same reference as Fig. 2)

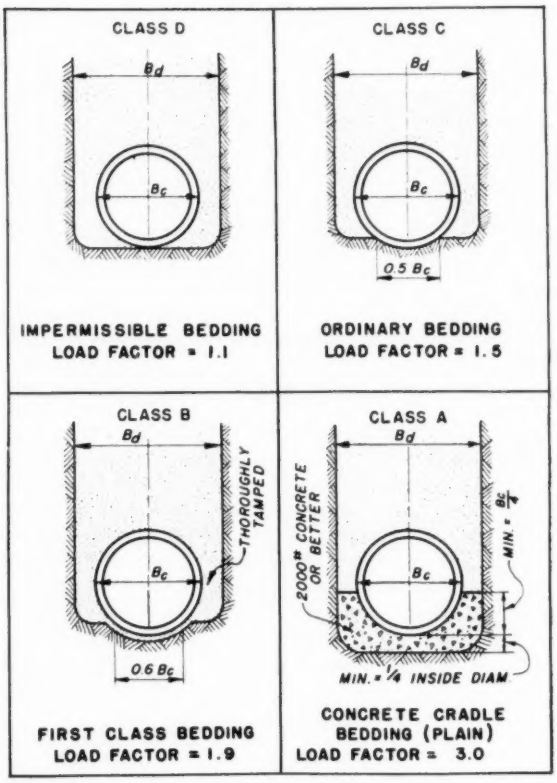


Fig. 4

The lower value, 1,130 lb per lin ft, is the design load to be used.

To determine the allowable depth to install 10-in standard quality tile (strength 1,200 lb per lin ft) in an 18-in trench for thoroughly wet clay proceed as follows using Fig. 2:

Projecting conduit: Using $B_c = 1.0$ and $W_c = 1{,}200$
Read on left line $H/B_c = 3.8$
$H = 3.8 \times 1.0 = 3.8$
$D = H + B_c = 3.8 + 1.0 = 4.8$ ft

Ditch conduit: Using $B_d = 1.5$ and $W_c = 1{,}200$
Read on left line $H/B_d = 5.5$
$H = 5.5 \times 1.5 = 8.2$
$D = H + B_c = 8.2 + 1.0 = 9.2$ ft

Since this example is the reverse of the previous case, the greater depth, 9.2 ft, is the maximum permitted.

(d) Allowable draintile depths for thoroughly wet clay have been tabulated (Table 1) for a wide range of field conditions. Depths given by Table 1 are a minimum and, therefore, safe for less severe soil conditions. Tile sizes, trench widths and tile strengths not shown in the table may be determined from Fig. 2. Nomographs in Fig. 3 are applicable for saturated sand.

(e) The loads which a tile will carry are not only influenced by the type of soil and the depth and width of trench, but also by the manner of bedding. This is brought out by the four methods of bedding illustrated in Fig. 4. Ordinary bedding is the method upon which the nomographs (Figs. 2 and 3) are based. Ordinary

TABLE 1. ALLOWABLE DRAINTILE DEPTHS

Tile size, in	ASTM class	Crushing strengths, lb per lin ft	Width of trench in inches 16	18	20	22	24	26	28	30	36
5	Standard	1200	16.5	8.7	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Extra quality	1600	Inf	Inf	12.2	9.5	9.5	9.5	9.5	9.5	9.5
6	Standard	1200	Inf	8.8	6.8	6.6	6.6	6.6	6.6	6.6	6.6
	Extra quality	1600	Inf	Inf	12.3	8.7	8.4	8.4	8.4	8.4	8.4
8	Standard	1200	Inf	9.0	7.0	5.8	5.4	5.4	5.4	5.4	5.4
	Extra quality	1600	Inf	Inf	12.5	8.8	7.3	6.9	6.9	6.9	6.9
10	Standard	1200	Inf	9.2	7.2	6.0	5.3	4.9	4.9	4.9	4.9
	Extra quality	1600	Inf	Inf	12.7	9.0	7.5	6.6	6.0	6.0	6.0
12	Standard	1200	Inf	9.4	7.3	6.2	5.5	5.0	4.7	4.7	4.7
	Extra quality	1600	Inf	Inf	12.9	9.2	7.7	6.8	6.1	5.6	5.6
15	Standard	1300			8.6	7.1	6.3	5.8	5.2	4.9	4.7
	Extra quality	1600			13.1	9.5	8.0	7.1	6.3	5.8	5.2
18	Standard	1400					7.0	6.5	5.9	5.5	4.7
	Extra quality	1800					9.6	8.5	7.5	6.9	5.7
21	Standard	1550							6.7	6.2	5.0
	Extra quality	2100							9.3	8.3	6.8
24	Standard	1700								7.1	5.9
	Extra quality	2400								10.0	7.9

Note 1 Values given for the various trench widths are depths of trench in feet.

Note 2 Crushing strengths given are averages in pounds per linear foot based on sand-bearing method, Specifications for Draintile, ASTM Designation C4-50T.

Note 3 These values allow a safety factor of 1.5.

Note 4 Width of trench is measured at top of tile.

Note 5 Loadings were computed for wet clay soil at 120 lb per cu. ft. Somewhat greater depths are permissible for lighter soils.

Note 6 Ordinary pipe laying whereby the under side of the tile is well bedded on soil for 60 to 90 deg of the circumference.

Note 7 "Inf" indicates infinity.

bedding is that in which the underside of the tile is carefully bedded in soil for 60 to 90 deg of the circumference, with the ditch bottom suitably rounded, and the tile blinded to a depth of at least 0.5 ft above its top, using care to fill the space at the sides of the tile with top soil. As indicated by the load factors, the supporting strength may be reduced from a value of 1.0 to 0.7, a loss of 30 percent, in the case of impermissible bedding and may be increased 20 to 30 percent by using first-class bedding with a load factor from 1.2 to 1.3. Use of the concrete cradle with a load factor of 2.0 will increase the supporting strength 100 percent over the values obtained by the nomographs in Figs. 2 and 3. First-class bedding should always be the first consideration where nominal additional supporting strength will be required of the tile. The most favorable factor will be obtained when this bedding is prepared as follows: The tile is laid on granular material (road gravel or crushed rock) in an earth foundation shaped to fit the lower part of the tile exterior for a width of at least 60 percent of the tile width. The remainder of the tile is entirely surrounded to a height of at least 1 ft above its top by this granular material carefully placed to fill completely all spaces under and adjacent to the tile. This fill is tamped thoroughly on each side and under the tile as far as practicable in layers not exceeding 6 in thick. If topsoil is substituted for the granular material, the load factor should not be assumed to be higher than 1.2. It will not be practicable ordinarily to use sticky clay subsoils in the manner recommended for first-class bedding.

To prevent overloading in deep and wide ditches it is sometimes feasible to construct with a trenching machine, or by hand, a subditch in the bottom of a wide ditch which has been excavated by a bulldozer, dragline, steam shovel, or backhoe. The width of the subditch measured at the top of the tile determines the load, and the width of the excavation above this point is unimportant. Therefore, any feasible method may be employed for removing the material above the top of the tile.

Another method to minimize overloading in wide trenches is to backfill only to a depth of 4 or 6 ft immediately after construction, then allow several months to elapse before completing the fill. If the trench is quite deep through rather short cuts, it is good practice to make the filling at intervals, allowing time for settlement between fillings. Backfilling in this manner, while helpful in reducing the overload resulting from wide ditches, should not be substituted for the use of tile with sufficient crushing strength to support the backfill load as calculated by the nomographs of Figs. 2 and 3.

When the calculated load requirements considerably exceed the crushing strengths for extra quality draintile of ASTM C4-50T, it will be exercising good judgment to specify pipe of higher strengths such as reinforced concrete sewer pipe (ASTM C75), reinforced concrete culvert pipe (ASTM C76), or extra strength clay pipe (ASTM C200). While these pipe will cost more per foot than draintile, it should be remembered that the number of feet required for extreme loading conditions is usually small in proportion to the total tile installed. In many cases the added cost, on a percentage basis, will be only nominal. Even this will be largely compensated through the saving effected in time for the ditching contractor, reflected back to the landowner, if the contractor can be assured when he bids for the job that there will be no overdue delays in his trenching operations caused by special requirements for the laying of the tile in the deeper and wider cuts.

7 *Spacing*

When a system of parallel tile laterals is used for field crops, the spacing between laterals should vary according to soil texture as follows:

Soil	Permeability	Spacing
Clay and clay loam soils	Very slow	30 to 70 ft apart
Silt and silty clay loam soils	Slow to moderately slow	60 to 100 ft apart
Sandy loam soils	Moderately to rapidly	100 to 300 ft apart
Muck	———	50 to 200 ft apart

The design engineer should specify the spacing for individual jobs within the above limits based on soil conditions, crops and local experiences. For some special or high-value crops spacings less than the minimum shown above can be justified. In some states a list of recommendations is available for tile lateral spacing according to individual soil types.

Additional information relating to depth and spacing of tile can be obtained from the following papers: "Proper Spacing and Depth of Tile Drains Determined by the Physical Properties of the Soil," J. H. Neal, University of Minnesota Technical Bulletin No. 101, June, 1934; "Soil Permeability as a Criterion for Drainage Design," V. S. Aronovici and W. W. Donnan, Am. Geo. Union, vol. 27, no. 1, February, 1946; "The Depth and Spacing of Tile Drains," C. S. Slater, AGRICULTURAL ENGINEERING, 31 : 448-450, 1950,

and "Depth and Spacing for Drain Laterals as Computed from Core-sample Permeability Measurements," Phelps Walker, AGRICULTURAL ENGINEERING, 33 : 71-73, 1952.

8 *Grades*

(a) Minimum. The minimum grade should be as great as possible on flat lands consistent with the topography of the area. Experience indicates that tile laid without grade or with very little grade tend to fill up readily. The grade of small-sized drains should be limited to the following:

Diameter of tile in inches	Minimum grade in feet per 100 ft
4	0.10
5	0.07
6	0.05

In some locations where fine sand or silt enter tile, a minimum grade to produce a velocity of 1.4 fps is recommended. This is equivalent to 0.3 ft per 100 ft for 4-in tile.

(b) Maximum. Steep grades causing high velocities of flow present a definite hazard to tile mains especially when they are flowing nearly full. Care must be exercised in laying of lateral drains on steep slopes. Where practical a designer should avoid placing mains on grades much over 2 percent. However, there are locations and conditions which require the use of steep grades. The following special practices are recommended for tile drains laid on steep grades in different soil materials; however, each individual case should be provided for by one or more special practices to meet the local conditions:

Sand and Sandy Loam: (1) Where the grade is less than 1 percent use appropriate construction methods described in Section III–10 for sandy soils; (2) where the grade is between 1 and 4 percent and line is running not over half full, lay tile to very tight fit and wrap joints with tar impregnated paper or heavy burlap and tamp heavy soil firmly in place around tile. (Applicable especially to laterals in stable soils; also select appropriate construction methods described in Sections III–10 or 11.)

Silt and Silt Loam: (1) On grades ranging from ½ to 3 percent, lay tile with tight fit and tamp heavy soil firmly in place around tile (See Section III–11); (2) on grades from 3 to 6 percent, running not over half full, lay tile to tight fit, wrap joints with tar impregnated paper and tamp heavy soil firmly in place in blinding tile. (Applicable to laterals particularly [see Section III–11].)

Clay Loam and Silty Clay: (1) On grades between 1 and 6 percent, lay tile to tight fit, tamp heavy textured soil firmly around pipe (see Section III–11); (2) on grades from 6 to 15 percent running not over half full, lay tile to tight fit, wrap joints with tar impregnated paper, tamp soil selected for its heavy texture firmly in place in blinding tile. (Applicable to laterals particularly [see Section III–11].)

Other Soil and Flow Conditions: For conditions where tile grades are steeper or the flow in tile exceeds limits specified in paragraphs above, an engineer should specify the method of protection required for the individual job. Such methods may include one or more of the following: Lay tile with tight fit, wrap joint with suitable material, blind tile with heavy-textured soil firmly around tile; encase tile in gravel; use sealed tongue-and-groove, bevel or bell end pipe, seal draintile with suitable cement material or use continuous pipe or fiber or metal.

The necessity for a breather near the beginning of a steep section and a relief well at the point where the steep section changes to a flat section should be considered. This will be determined by the velocities in the tile, the soil in which the tile is laid and the capacity of the tile below the steep section with respect to that in the steep section. If the capacity of the tile in the flat section is such that the hydraulic gradient will reach nearly to the surface of the ground for full tile flow, a relief well should be installed to prevent a "blowout."

9 *Alignment*

Change in horizontal direction should be made by one of the following methods:

(a) A gradual curve of the tile trench on a radius that the trenching machine can dig and still maintain grade. The radius will vary with the depth of the trench; however, in no case should less than 50 ft be used. Follow recommendations on "Joints," Section III (9), with respect to the gap between tiles on the outer side of the curve.

(b) The use of manufactured fittings.

(c) The use of junction boxes and manholes.

10 *Connections*

Manufactured connections or branches for joining two tile lines should always be used when available. If connections are not available, the junction should be chipped, fitted and sealed with cement mortar. Laterals should be connected into the main tile at the midpoint of the tile. On large tile lines it is a good practice to lay a submain parallel to the main for collecting the lateral lines as this eliminates the necessity of tapping the large main every 50 to 100 ft. The saving on large connections and length of laterals will generally offset the cost of the submain.

11 *Tile Outlet Protection*

When the tile main outlets into an open ditch, the end of the tile should always be protected against erosion and undermining. Two conditions are involved:

(a) When no surface water will enter the ditch at the location of the tile outlet. Under this condition a section of continuous rigid pipe should be used. At least two-thirds of its length, or a minimum of 8 to 12 ft should be embedded into the ditch bank with the overhanging length discharging just beyond the toe of the ditch slope. When the placement of a pipe projecting into the ditch will cause a serious ice jam or be damaged by floating ice or debris, the pipe should be recessed into the ditch bank and provision made for the water to flow from the pipe out onto a paved section or apron of a small concrete or masonry structure. If a continuous rigid pipe is not available, a wooden box made of 2-in planks (preferably creosote pressure-treated) and of the same length as that specified for pipe can be used. Under certain conditions it may be advisable to use sewer pipe with cemented joints and cradled in concrete with the outlet end recessed as noted above.

(b) When surface water must enter the ditch at the location of the tile outlet. Under this condition some type of structure should be used to outlet the tile and to safely lower the surface flow to the ditch. When there is no spoil bank, the straight-drop spillway is generally the best type of structure. If there is a spoil bank and suf-

ficient temporary storage on the land is possible and permissible, a pipe drop-inlet structure will usually provide the best and most economical installation. Sometimes it may be possible to move the tile outlet out of the waterway or divert the surface water to another location at least 60 to 75 ft away and lower the surface flow into the ditch over a sodded chute. When practical the tile outlet should be located upstream from the surface-water outlet. The tile outlet should then be protected by a pipe as specified under *(a)* above.

Swinging gates or a similar type of protection should be used on all outlets to exclude small animals unless the outlet is so located that it would be impossible for them to enter the tile at the outlet end. Gratings or attached screens should never be used on tile lines that have surface inlets because of the hazard of debris which might enter through the inlets and collect on the grating bars. In some areas plant roots, such as sugar beet roots, present an additional hazard.

12 *Junction Boxes*

Junction boxes should be used where more than two tile mains join or where two or more laterals or mains join at different elevations. Where possible, junction boxes should be located in permanent fences or in non-cultivated areas with the cover above ground to provide easy access for inspection. If the junction point is in a cultivated field, the box should be constructed so that the top is at least 18 in below the surface of the ground. It can then be capped over with soil and its location "referenced in" so that it can be readily located.

13 *Relief Wells (Stand Pipe)*

Relief wells serve to relieve pressure in the line that might otherwise cause the tile line to blow out. A relief well can be constructed by placing a T connection in the line and cementing sewer pipe vertically into the T. The pipe should extend about one foot above the ground unless provisions have been made in the design for it to serve also as a surface inlet. The exposed end of the pipe should be covered with heavy wire mesh or some type of grating. The size of the riser tile should be equal to the diameter of the tile line or one or two sizes smaller, depending upon the amount of overload.

Relief wells should be located as follows:

(a) At points where the tile line might become overloaded for a short period of time such as at the end of a steep section as noted in Section II (8).

(b) On lines that have surface inlets and particularly below large surface inlets.

(c) They can sometimes be used to advantage in improving existing mains that are temporarily overloaded causing blowouts. However, the installation of a relief line paralleling the existing main should be the first consideration.

14 *Surface Inlets*

Surface inlets always add another hazard to the maintenance of a tile system and should be used only when the construction of waterways to remove the impounded water is not feasible or is impractical. It is good practice to locate the inlet on laterals or at least 20 ft to one side of the main since inlets are a frequent source of trouble. All open-surface inlets should be provided with some type of grating to exclude coarse debris. All open surface inlets should be provided with a sediment trap or a built-in sediment trap should be located immediately downstream from the inlet at some convenient location.

15 *Sediment Traps*

Sediment traps should be used on tile lines that extend through fine sand pockets or extended sandy areas where there is a tendency for fine sand to enter the tile through the tile joints. They should also be used in connection with open surface inlets as specified in the preceding paragraph. The sediment trap should be so constructed that a storage area is provided below the grade line of the tile for collecting the sediment that is carried into the trap by the incoming tile line. Some type of baffle or 90-deg tile elbow attached to the outlet tile line should be used to promote desilting.

16 *Interception of Seepage*

Hillside seepage should be removed by locating the tile line across and intercepting the path of flow. The tile line should be placed approximately at the impervious layer along which the seepage water travels.

17 *Trees*

Where possible all water-loving trees, such as willow, elm, soft maple and cottonwood should be removed for a distance of approximately 100 ft on each side of the tile line. A clearance of about 50 ft should be maintained from other species of trees. If the trees cannot be removed or the line rerouted, a closed tile line should be constructed of sewer pipe with cemented joints and this type of construction should extend throughout the root-zone area of the tree or trees. However, orchards are sometimes drained by tile, but the life of the drain may be limited.

18 *Plan*

A plan should be prepared for each tile installation by the designer for use of the contractor during construction and for the owner as a record of the installation. It is desirable that this record be filed with the abstract or deed. The plan should include a map of the installation showing accurate location and size of all tile lines and appurtenances installed together with a profile or copy of the staking notes on the mains and submains.

SECTION III. CONSTRUCTION

1 *Setting Grade Stakes*

Stakes to govern alignment and grade should be set 100 ft or less apart on straight lines and 50 ft or less on curves for all tile lines to be constructed. Grade stakes should always be set with an engineer's level.

2 *Setting Targets*

Targets should always be used as a guide by which to finish the tile trench bottom to exact grade on all tile-line construction. Targets should be set at not less than three stakes along any given strip of continuous grade at one time. Key targets should be set at 500-700-ft intervals, or at points of change in grade, as required by each respective grade stake. Intermediate targets may be set in correct position by carefully sighting between key targets. Then each target should be checked for depth of cut as indicated by its respective grade stake.

3 *Starting Point*

Installation of all tile lines should begin at the outlet and progress upstream.

4 *Trench Width*

The minimum trench width measured at the top of the tile should not be less than the outside diameter of the tile plus 0.5 ft.

5 *Tile Bed*

The tile bed should be in accordance with the recommendations given in Section II (6e).

6 *Trench Alignment*

On straight lines the tile trench should be excavated true to the line as staked. On curves the trench should be excavated on a true curve and not on chords with sharp turns at the stakes.

7 *Correction for Overdigging Grade*

If the trench is excavated below tile grade, it should be filled back either with graded gravel or well-pulverized soil which must be tamped sufficiently to provide a firm foundation. The bottom of the trench must again be planed to grade and shaped.

8 *Laying the Tile*

Each tile should be laid true to line and grade and firmly bedded in the bottom of the trench, except as provided in Section III (16). The tile should be kept laid up to within a few feet of the finished trench. Where necessary, the tile should be turned on its horizontal axis so that there is no misalignment of the tiles at the joints, either vertically or horizontally.

9 *Joints*

The tile should be laid so that the gap between tile will conform as nearly as possible to the following recommendations:

(a) Sandy Soil (Tight fit). The tile should be laid and turned to avoid excessive cracks at the joints. They should be fitted together as tight as will result when three tiles of the smaller diameters, after laying, are butted together by shoving with the foot on the end of the last of the three laid. Larger tile may be shoved together by using a board of moderate length as a pry.

(b) Silt and Loam Soil. About ⅛ in.

(c) Clay Soil. ⅛ in, except where local experience indicates wider spacing.

(d) Peat and Muck. ¼ to ⅜ in.

When the kinds of soils listed in *(b)*, *(c)* and *(d)* above are encountered, care should be exercised in the placing of the tile so that the joint spacing falls within the ranges given. This is important, as tight joints will seal over and joints that are too large will permit soil to be washed into the tile. These conditions can be overcome by special blinding as outlined in paragraph 17 of this section (Section III).

Where large gaps occur between tile, as on the outer side of a curve in the tile line, the joints should be covered with broken pieces of tile or in some other equally acceptable manner.

10 *Construction Features in Sandy Soils*

When sandy soils are encountered, special construction features are required depending upon the type and condition of the sand as follows:

(a) In fine sandy soil where the trench bottom is stable, the following recommendations should be followed:

(1) Use only good quality tile, uniform in shape and size with smooth ends.

(2) Lay the tile so as to secure the snuggest fit possible.

(3) The upper two-thirds of the joint should be covered with burlap, building paper or other acceptable material to prevent the fine material from entering the drain.

(b) In soils containing quicksand (water-bearing sand) extreme care must be taken to exclude sedimentary material from entering the tile and to secure uniform grades in firm foundations. The following factors should be observed when draining these soils:

(1) Construct tile drains only when soil profile is in driest possible condition.

(2) Select only tile of exceptional quality with regard to uniformity in size, shape and smoothness of ends.

(3) Cover the upper two-thirds of joints with coal-tar-saturated building paper.

(4) When the objective is to extend tile through quicksand pocket only, sewer tile calked with oakum or continuous rigid pipe may be used in place of draintile. When using metal pipe, joints should be wrapped with coal-tar-saturated paper and clamped with regular manufactured connecting bands.

(5) Filters are recommended in localities where filter material may be secured readily. Frequently well-constructed filters serve also to stabilize subgrade. The following types of filters and stabilizing materials have been successful:

(a) Construct a gravel envelope by placing enough graded gravel or crushed limestone in trench to stabilize subgrade, lay tile, place coal-tar-saturated paper and cover with the graded stone.

(b) Excavate below grade to a sufficient depth to encase the tile line with at least 4 in of a stable soil, either loam, clay or mixture of the same.

(c) Place good, tough sod in bottom of trench and lay tile on this. Then completely cover tile with sod.

(6) In some of the worst quicksands, filters do not furnish adequate support of tile for maintaining uniform grades. Tile should be placed in cradle when draining these soils.

The cradle is constructed by placing wooden plank in bottom of ditch and nailing strips along top edges to form trough for tile. Width of plank should be approximately equal to the outside diameter of tile. Junctions of boards and strips are staggered in order to give rigidity to cradle and thereby furnishing continuous support throughout its entire length.

Occasionally it is necessary to place cradle on piling. Piling is constructed by driving pairs of posts along edges of trench. Posts should be driven deep enough into the subgrade material to become firm. Crosstimbers of 2 x 2-in material nailed to opposite posts support the cradle.

(7) Sheet piling, pumping, freezing and various other means have been used to install pipe in unstable soils. Without exception, all such methods are so expensive that none can be justified except in cases of outlets which serve unusually large areas of real or potentially high-priced lands.

11 *Construction Features for Mains or Steep Grades*

Special construction features to maintain alignment of mains or steep grades should be used in locations as specified in Section II (8). These special features shall consist of:

(a) Use only tile uniform in size and shape with smooth ends.

(Continued on page 485)

Land Preparation by Leveling

J. W. Borden
MEMBER ASAE

OF ALL the problems directly affecting actual crop yields and farm income, the subject of proper land preparation, as it pertains to improving irrigation and surface drainage, has probably been given the least attention. Over the years farmers have learned how to plow, seed and fertilize to improve their yields, and the research and development studies on seed, which have led to hybrid seeds and greater germination, have all contributed to increasing the yield per acre. It was somewhat startling, however, to learn on the authority of the U. S. Department of Agriculture that in recent years, even with the advent of hybrid corn and the extensive use of commercial fertilizers, the average yield for that crop had been increased only 10 bu per acre. This same report stated that within a few years an additional increase of 8 bu per acre must be realized to supply our growing population with sufficient corn. In coming years we can achieve at least some of the yield increase necessary by paying closer attention to land preparation for better irrigation and better surface drainage.

In past years insufficient land preparation has been done in the irrigated areas. The ground surface which was left to us by nature is seldom suited for the efficient application of water. In general, we have accepted the topography of the fields as it existed, and irrigation systems were designed to fit the natural topography of the ground. This resulted in smaller fields with a hodgepodge of row directions. In many cases water was put on slopes which were too steep for irrigation. The ultimate result was noted in three distinct ways. Serious erosion problems resulted. Excessive amounts of labor and water were necessary for water distribution. Waste water at the lower ends of the field created drainage problems. In this connection, it is interesting to note that over 20 per cent of the total irrigated land area in Colorado is included in drainage enterprises which were organized primarily to rid the land of seepage from overirrigation, and for control or prevention of alkali accumulation. In recent years there seems to be a tendency throughout the irrigated territory of the United States to look before leaping, and to develop definite land-preparation plans. Also, for the first time, a section was added to the 1952 agricultural conservation program for "shaping or land grading to provide permanent slopes needed for surface drainage." If the farmer, through consultation with his local technicians, will formulate a definite plan, he can modify the land surface and predetermine the irrigation system so that he can obtain uniform slopes, eliminate the practice of irrigating steep slopes, reduce the number of fields, and, consequently, the number of row directions, and, of utmost importance, irrigate his fields with less labor and by using less water.

The Leveling Operation. After a farmer has consulted with his local technical agencies and decided on an irrigation system which is efficient, his next consideration must be preparation of the ground surface by leveling. The extent to which the ground surface should be leveled depends largely on the depth of soil and the cost of leveling. Where high-value crops are grown, and where the farmer has capital to invest for the work, the quickest way for him to get into crop production is to hire heavy-duty equipment from either local contractors or his soil conservation district. If movement of large yardages of earth is not necessary, then it is entirely feasible, with present-day machines, for the farmer to do his own grading and finishing work.

The object of land leveling is to achieve efficient irrigation by moving the least possible yardage of earth. The ideal sought in handling irrigation water is to allow the water to spread as evenly as possible over the field surface, and to carry off any excess gently with a minimum loss of top soil. When referring to leveling, we actually have in mind two separate operations. First is earth moving or grading, which consists of actually cutting off the ridges and filling in the low spots to rework or revise the general slope of the field.

At this point it might be well to consider the question, "How much can the farmer spend for grading to change the slope of his fields?" In the higher altitude farming communities, which have short crop seasons, many farmers have exceeded the practical limits of expense on earth-moving projects. These farmers may have read or heard of a project similar to their own, in yardage moved and expense, in Arizona or the Imperial Valley or San Joaquin Valley of California. They fail to realize that in these latter territories, several high-value vegetable crops are grown each year, which justify a high expense for drilling and pumping water, and for moving earth. The practicability of such a job must, of course, have been pre-

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The author — J. W. BORDEN — is vice-president, Eversman Mfg. Co.

A land leveler in use in the corn belt for smoothing land to improve surface drainage

determined in the farm plan and by proper consultation and investigation on the part of the local technicians. There seems to be a definite tendency on the part of operators in the highly productive areas to stock-pile the top soil on fields which require deep cuts. By pulling the good soil to the side, making the cuts and fills necessary, and then returning the top soil to both the cut and filled areas, they can put land into production much sooner. It is expensive but not nearly so costly as having 5 ft of good soil in the holes and barren spots in the rest of the field.

There are various methods of accomplishing the land-grading work, depending entirely on the individual job. If the cuts are small — under 6 in — and the longer hauls are around 300 ft, it is possible to do this work with a land leveler or small scraper, used with the tractor on the farm. Levelers are available in a range of sizes. This enables the smaller farmer with a small wheel tractor to accomplish as perfect a job on his fields as the larger operator who might be in a better position to hire or buy heavier equipment. One farmer has stated that he had his 12-year-old son remove a ridge in his fields which was over 5 ft high and 160 ft long. We have found in a good many sections of the country that it has been extremely difficult to get farmers to accept the idea of leveling by hiring heavy equipment. They have shown much more interest and willingness to accomplish the job when the emphasis by the local technicians was shifted in the direction of having the farmer do this work with small equipment on his own time. On our own experimental farm near Denver, we conducted a leveling project in the fall of 1949. With a Farmall M tractor and a Model 289 Eversman leveler, we moved 5500 cu yd of dirt and finished the work at a cost of $347. This figure included the tractor operator's wages. A 6-yd carry-all, available to the district, would have done this work in considerably less time. The estimate on this yardage was $732. What is more important, however, after this cash had been paid out for hiring the carry-all and tractor, some kind of finishing tool would still have to be purchased or rented in order to complete the job.

STAKE OUT FIELD IN RECTANGULAR COORDINATES

It is normally necessary to stake out the field in rectangular coordinates, the stake lines being placed at either 50 or 100 ft, depending on the condition of the field involved. A topographical survey is then made by the local technician, or in some cases by the farmer himself, and an accurate topographic map made. In many instances, a careful analysis of the topographic map will disclose that portions of the fields can be balanced for short hauls. That is, the yardage in adjacent cuts and fills will be about equal so that these adjustments can be made by shorter trips and possibly save many hours of field work. As soon as the cuts and fills are figured, these are marked on the individual stakes and the actual field leveling can proceed. It is wise to re-survey the field after grading and finishing. However, if this is not done, there is no doubt in the farmer's mind as to where a mistake was made the first time he attempts to irrigate. When extensive grading has been done, the farmer will undoubtedly improve his field by deep chiseling and by planting soil-building crops before he attempts to go immediately into high-production farming.

The second step in leveling, after grading has been accomplished, is what we refer to as finishing, automatic leveling, planing or floating. It eliminates minor surface irregularities and prepares a fine-textured, firm and fertile seedbed.

With the precision land-leveling equipment now available for almost any size of farm tractor, every farmer can prepare his fields for efficient irrigation. As a result, the crop yield increases, often to double, and as much as 10 to 25 per cent less water is necessary to irrigate the fields. The land, quite naturally, builds up in quality and value, and expensive time and labor is saved on properly leveled fields. The cost of the leveler is repaid over and over again as it is used each year. In the irrigated sections of the United States, many farmers realize that they must level first, then plant. The savings in time necessary to irrigate each piece of land are substantial. Valuable water can be saved and the flow of water from one end of the rows to the other is achieved.

FINISHING OR AUTOMATIC LEVELING

It is important also to think of the finishing or automatic-leveling operation in terms of the maintenance or continuing year-to-year leveling work, which is as necessary as the original job of preparing the land for irrigation. The ground surface is disturbed from season to season by normal farming operations, by wind, by heavy rains, and by one-way plowing. These irregularities in the ground surface can totally erase the benefits of the grading job if floating the surface is not done every year before planting. Considerable cash outlay might be saved by not using the carry-all to finish fields to the final degree, but doing the finishing job necessary with smaller equipment which can be handled with the farmer's own tractor, and on his own time. A soil conservation district in Colorado reports that their leveling practice is to do all the heavy cutting and a rough leveling job with carry-all equipment and then follow up to obtain the final degree of perfection with a leveler. They have found that this method has lowered their farmers' leveling cost at least 3c per cu yd. This represents a sizeable saving to the farmer. It is impossible to overstress the importance of maintaining the fields once they are prepared for irrigation. It is common to observe fields in which yields have been reduced 25 to 30 per cent by improper water distribution.

Land-Leveling Equipment. There are many types of earth-moving equipment. Careful thought and planning should be done in order to obtain the tools best suited to the particular work. The carry-all scraper is more economical if the job involves moving large quantities of soil over a considerable distance. In this category there are carry-alls available for use with every size of tractor from two-plow up. If large volumes of earth are to be moved over a shorter haul, then the semicarry-all, drag scraper, roll-over scraper, or possibly even the bulldozer, can be used effectively. For the finishing or floating work, a variety of levelers and planes are available. Even the homemade wooden drag has its place, and while it is not very efficient, it is the inception at least of better land preparation and seedbed construction. Where farmers are found who feel they cannot afford a manufactured leveler, it is most earnestly suggested that they construct their own wooden drag, since use of this tool is better than *(Continued on page 498)*

The 1953 ASAE Gold Medalists

The American Society of Agricultural Engineers awarded the Cyrus Hall McCormick Medal to Andrey A. Potter and the John Deere Medal to Orson W. Israelsen at Pittsburgh, Pa., on June 17

A. A. POTTER

O. W. ISRAELSEN

NO DOUBT the Jury of Awards of the American Society of Agricultural Engineers hewed to the line of agricultural engineering achievement in choosing Andrey Abraham Potter to receive the Cyrus Hall McCormick Gold Medal for 1953. But overshadowing the merit of his professional achievement is the inspiration of his life, his stature as a great American—and that not as a native son but as an adopted child.

It was in Vilna, Russia, on August 5, 1882, that Andrey was born the son of Gregor and Rivza (Pelonsky) Potter. He came to America at the age of fifteen. Yet before that—when he was twelve and his family was living in Europe—he read in French translation the autobiography of Benjamin Franklin. And so, before he set foot on these shores, he began to be an American, for in those pages he saw something of the spirit and meaning of America. Small wonder that among his almost countless honors was the Americanism Award in 1950.

Following graduation as a bachelor of science from Massachusetts Institute of Technology in 1903 he worked two years for General Electric at Schenectady, N. Y., a connection he renewed in 1913 for a shorter period at the General Electric plant at Lynn, Mass. This latter was hardly a hiatus in his career of fifteen years at Kansas State College, begun in 1905, where he started as assistant professor of mechanical engineering.

In due course he became full professor, and in 1913 was made dean of the division of engineering as well as director of the engineering experiment station. The year 1913 was notable, too, for first publication of his book "Farm Motors," which has gone through several editions and continues as a classic text.

Dean Potter's share in the advancement of agricultural engineering is all the more remarkable since the record reveals no direct connection or formal title within the profession. But oldsters recall that about 1910, before the farm tractor was out of its swaddling clothes, Professor Potter sponsored a tractor plowing contest near Hutchinson, Kansas — and no matter now that it *(Continued on page 484)*

CHOICE of Orson W. Israelsen by the Jury of Awards of the American Society of Agricultural Engineers to be the John Deere Gold Medalist for 1953 might well be based on any of three aspects of his career—research, teaching, or practicing and consulting engineering. Yet somehow the height of his attainment seems overshadowed by the lofty rectitude and fortitude of his personality, his caliber as a man.

Orson W. Israelsen was born December 25, 1887, in the Cache Valley at Hyrum, Utah. His parents were immigrant pioneers of humble estate. Growing up as a farm boy he did his share of chores and other farm tasks. When the time came that he needed a picture to appear in his high school yearbook, he earned it by building a pasture fence for the photographer.

He was graduated a bachelor of science in 1912 from Utah State Agricultural College. He had started in business administration, partly at the suggestion of a lifelong girl friend. Before the year was out, inspired by the vision of the late Dr. John A. Widtsoe, he pointed his studies toward irrigation science and engineering. But the girl friend still got the last word. In his junior year she married him, took in boarders, and became his partner and assistant for all of the years thereafter.

Continuing his studies at the University of California, he took a master's degree in irrigation engineering in 1914. There, too, after a later sojourn, "by original research in irrigation" he received his Ph.D. in 1925. Meanwhile, during much of 1913, he had begun studying distribution of water in soil for the U.S. Department of Agriculture, and continued similar studies for the University of California during 1914-16.

In the summer of 1916 Dr. Israelsen returned to Utah State Agricultural College as a member of the faculty, and there—except time out for his doctorate study in California —he has continued ever since. After assistant and associate professorships he became, in 1919, professor of irrigation and drainage engineering. For some eighteen years he has been head of the department, and has served as acting dean

of the school of engineering. In the allied agricultural experiment station he has held research professorship parallel to the teacher's rank in the college.

Almost from the start, beginning the summer of 1917, he has been repeatedly, almost regularly, in active or consulting practice. A list of more than thirty engineering engagements show them to run from a few days to several years, some overlapping and some still continuing. Geographically they range from Canada to Brazil, though most of them are in his own or neighboring counties or states.

Dr. Israelsen designed the hydraulic laboratory for the school of engineering in his own college, drainage and culinary water systems for towns of Newton and North Logan, as wel as drainage and irrigation improvements for a considerable number of districts, counties and corporations. As engineer, consultant or collaborator he has served federal agencies including the Land Bank of Berkeley, the USDA bureaus (when they were separate) of agricultural engineering and of plant industry, and the Soil Conservation Service.

AGRICULTURAL ENGINEERING ASPECTS OF WATER

Naturally most of his connections were with water companies, drainage districts, and kindred entities concerned with agricultural engineering aspects of water. A slight exception was a coal company for which he was consultant on pumping ground water for domestic and industrial uses.

To those who know of Dr. Israelsen only by his works, it may well be an astounding revelation that for more than half his professional career he has heard no sound whatsoever. It was in May, 1928, that he was stricken with epidemic spinal meningitis, of such severity as to imperil life, and with dramatic abruptness—a matter of minutes—passed forever into a world of complete silence. Colleagues and personal friends marvel at his mastery of new modes of communication, and his fortitude—almost to the point of nonchalance—in making the necessary adjustments in modus vivendi. Outside those personal circles there has been no apparent change in his activities and achievement.

As one of the West's (if not the world's) highest authorities on water in dry regions, it was almost inevitable that he should become an expert witness in court cases arising from conflicting interests and conflicting ideas as to rights in and use of precious water. Backed by the immensity of his technical knowledge and the orderly, albeit at times laconic, manner of his mind, his lack of hearing helped him to become something of a modern oracle.

As an author, Dr. Israelsen is perhaps most widely known for his textbook "Irrigation Principles and Practices," first published in 1932 and still a standard—if not *the* standard—work on the subject. In a bibliography listing him as sole author of 31 titles and collaborator in 38 he deals with practically every aspect of irrigation water, from its sources on and under the ground, through canals and courts, its behavior in soils and in living plants, and finally its disposition by drainage. He has written alike for farm papers and experiment station circulars, and for the most learned of technical journals, among them AGRICULTURAL ENGINEERING.

Now a Life Fellow, Dr. Israelsen became a member of the American Society of Agricultural Engineers in 1914, at the threshold of his professional career. He is a past-president of the Utah Academy of Science, Arts and Letters. Other memberships include American Society of Civil Engineers, American Association for the Advancement of Science, American Geophysical Union, American Society for Engineering Education, Idaho Reclamation Association, the International Mark Twain Society, and the societies of Sigma Xi and Phi Kappa Phi.

In addition to Dr. Israelsen's accomplishments as an irrigation and drainage engineer, many of his students say that his greatness lies in his influence on the lives of young engineers. He has the unusual ability to teach engineers how to study, to convince them that work should be pleasure, rather than drudgery, and that success is measured by accomplishments, and by contributions to the public welfare, more than by the accumulation of money.

He has been much more than a teacher. He has been a "second" father to students—guiding, counseling, encouraging and inspiring. Years after students have completed their work in his classroom, they call at his home with the same freedom and fondness that his own children do. His students, who have excelled in many engineering fields, are a monument to his greatest contribution to society.

He is an active member and has held various positions in the Church of Jesus Christ of Latter Day Saints. He and his wife, the former Jennie Mae Allen, have six surviving children and nine grandchildren. He is known as a horseman at home in the saddle, a huntsman who brings back his deer, and a chess player at whose hearth are welcomed opponents from the wide world, kindred spirits among his students who hail from far-off lands.

Andrey A. Potter

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was pretty well rained out. It was in those years that he sensed the significance of engineering in agriculture, and nurtured the profession in its infancy. He was responsible for establishment of the professional curriculum at Kansas State—one of the very first few both in establishment and in accreditation by the Engineers' Council for Professional Development.

Perhaps more important than his own pioneering has been his steady and sturdy support of agricultural engineering in the Association of Land-Grant Colleges and Universities whereby these institutions in 17 states now have fully ECPD accredited curriculums. Similarly helpful was his support during his chairmanship of the Committee on Engineering Schools of ECPD.

In 1920 Dean Potter left Kansas to become dean of the engineering schools and director of the engineering experiment station at Purdue University, his present position. During 1945-46 he bore added duties as acting president of the University, president and director of its aeronautics corporation, and its research foundation.

Besides his bachelor's degree, he holds honorary doctorates as follows: In engineering from Kansas State College, Rose Polytechnic Institute, South Dakota School of Mines and Technology; in science from Alfred University, Northeastern University, and Northwestern University; in laws from Norwich University. He has been a member of Sigma Tau, Tau Beta Pi, Phi Kappa Phi, Sigma Xi, Scabbard and Blade. He is a Mason 33°, honorary Rotarian, Republican and Presbyterian. *(Continued on page 485)*

Design and Construction of Tile Drains

(Continued from page 480)

(b) Lay the tile so as to secure the snuggest fit possible with the inside diameter of one tile matching that of the adjoining tiles.

(c) Tamp clay carefully under and around the tile before backfilling.

12 *Keeping Tile Clean*

The tile should be kept clean while laying. All dirt in the tile should be removed before the next tile is laid.

13 *Ledge Rock*

When ledge rock is encountered at grade, the trench should be excavated to a depth of about 6 in below grade and this space filled with graded gravel. Then the bottom of the trench must be shaped and planed to grade.

14 *Protection During Construction*

At the end of each day's work the end of the tile line being placed should be completely closed by a wooden or metal plate or some other device to prevent sediment or debris from entering the line in the event of rain. The ends of all tile drains should be tightly closed with a plate, brick, or some other suitable material.

15 *Inspection*

All lines should be carefully inspected prior to backfilling to determine if they are true to grade, alignment and other specifications that apply to the particular job.

16 *Allowable Variation from Grade*

The constructed grade must be such that the tile line as constructed will provide the capacity required for the area to be drained in accordance with Section II (2). This means that a slight decrease of the grade can be tolerated when the required capacity is equal to or less than the actual capacity of the tile on the decreased grade. A slight "sag" in the grade line is less harmful than a "hump" in the line. A gradual change over a distance of not less than 30 or 40 ft with a deviation of 12½ to 15 percent of the interior diameter of the tile for sizes up to 8 in and 8 to 10 percent for tile sizes over 8 in generally will not result in any appreciable reduction in the carrying capacity of the line. However, a "sag" and a "hump" of the above percentages, both occuring within a distance of 100 ft should not be permitted.

17 *Blinding*

Blinding consists of placing around and covering of the tile to a depth of from 6 to 12 in with loose, mellow topsoil. Sand should not be placed directly on or around the tile. Blinding should follow soon after the tile are laid. All tile laid should be blinded by the end of any day's work. Care must be exercised during the blinding operation so that batted joints and alignment of the tile are not disturbed. In tight soils or where suitable topsoil is not available a layer of several inches of well-graded gravel or coarse cinders spread over the tile prevents the joints from sealing and facilitates drainage. Hay, straw, corncobs or other vegetative material can be used as a covering for the joints, but the period of usefulness of these materials is limited.

Acceptable methods of machine blinding and backfilling can be used provided the soil is not sandy, is of average permeability and contains no large stones that might damage the tile when falling into the trench.

18 *Backfill*

The backfilling of the trench should be completed as rapidly as is consistent with the progress of the work, and should always be done before the backfill material freezes. All earth removed from the trench should be returned to and heaped above the surface of the ground at the trench in such a manner as to insure against objectional depressions once settlement has taken place.

Andrey A. Potter

(Continued from page 484)

In the realm of technical and professional memberships, with honors and responsibilities appertaining, Dean Potter's record defies brevity. His presidencies include American Society of Mechanical Engineers, the Kansas and Indiana engineering societies, American Society for Engineering Education, American Engineering Council, and Bituminous Coal Research, Inc.

As other officer, trustee or chairman of important activity, he has served the American Association for the Advancement of Science, Engineers' Council for Professional Development, Engineering Foundation, and Association of Land-Grant Colleges and Universities. Honorary memberships include several of the foregoing and the American Association of University Professors, National Association of Power Engineers, and Institute of Traffic Engineers.

On advisory boards or in comparable capacities he has served the Association of American Railroads, National Electric Light Association, U.S. Naval Consulting Board, U.S. Bureau and later U.S. Office of Education, National Resources Committee, National Patent Planning Commission, and other state and federal bodies of kindred sort. He is now serving as a member of the National Science Foundation Board. He has served his alma mater, MIT, as a member of the visiting committee on mechanical engineering and on the panel for its mid century convocation.

Besides his pioneer text on farm motors, Dean Potter is author of authoritative books on elements of steam and gas power, and on engineering thermodynamics, also a contribution to American problems of reconstruction, dated 1918. Through the years he has written more than three hundred articles for engineering and educational publications.

Besides his present honor, and the Americanism Award already mentioned, Dean Potter was the Lamme Medalist in 1940, winner of the Washington Award, Northwestern University Centennial Award, and the U.S. Navy Distinguished Public Service Award in 1943. It may well testify to the measure of the man that amid the breadth of his activities, rising to high honor in several fields, he now attains one of the two top awards in agricultural engineering.

Dean Potter's wife was Eva Burtner, of Manhattan, Kansas, whom he married in 1906. Their children are James Gregor, a physicist, and Helen, an economist. As to hobbies, the dean mentions music, reading, writing—and young people. Others mention that he plays the ocarina, and that he always makes occasion to be friendly with little children.

Here, perhaps, we come to the intangible which has made Dean Potter not only a great engineer but a great teacher of engineers—his human qualities that have inspired as well as instructed his students, that have earned the affection as well as the respect of colleagues. As a loyal son of his adopted land he has been a wise and elder brother to generations of its youth.

NEWS SECTION

Fruitful ASAE Annual Meeting

AGRICULTURAL engineers from wide areas of the United States, Canada, and a few other countries gathered at Pittsburgh, Pa., June 14 to 17, for the 46th Annual Meeting of the American Society of Agricultural Engineers. Total attendance added up to around 700.

Location of the meeting in a center of production of engineering materials and equipment was reflected in the program. Tuesday afternoon and Wednesday forenoon tours to nationally known manufacturing plants and research laboratories in the Pittsburgh area proved exceptionally popular. Those visited included the Alcoa plant, U.S. Steel Irwin Works, Gulf Oil research laboratories, Westinghouse Electric East Pittsburgh plant, Mellon Institute of Industrial Research, Jones and Laughlin Steel Southside plant, American Steel and Wire Rankin Works, Gardner Displays Co., H. J. Heinz Co., Pittsburgh Forgings Coraopolis plant, Mine Safety Appliances Co., Pittsburgh Screw and Bolt Co., and McDowell Mfg. Co.

Registration of early arrivals started Sunday at 1:00 p.m. and continued throughout the afternoon. By evening an estimated 300 were on hand for the buffet supper and entertainment.

A second get-acquainted opportunity was provided Monday evening at the sponsors farm party and dance. Games, dances, and a spirit of informality were the rule of the evening, and for the remainder of the meeting everyone attending that event could assume that he had met everyone present.

J. B. Stere, chairman of the 1952-53 Meetings Committee, officially called the meeting to order Monday afternoon, for the opening general program, and introduced Ivan D. Wood, president of ASAE, who presided. Mr. Wood introduced David F. Austin, executive vice-president (commercial), United States Steel Corporation, as the featured speaker. Mr. Austin's message on "Free Enterprise — Our Heritage and Our Hope" was well received.

Mr. Wood then delivered the President's Annual Address. In developing his title, "New Frontiers for Engineers," he called attention to conditions, achievements, and challenges in the agricultural engineering field as they impressed him during his year as president of the Society and from a lifelong background of experience and contacts as an agricultural engineer.

At the Annual Business Meeting of the Society which followed, considerable attention was given to matters of cooperation with the American Society for Engineering Education and with the Engineers' Council for Professional Development.

The second general session Wednesday afternoon, sponsored by the College Division, featured an exposition of "How Not to Present a Technical Paper," by L. N. Rowley, Jr., editor of *Power*, McGraw-Hill Publishing Co. Illustrations of common errors led up to positive recommendations for the engineer with limited or infrequent practice in public speaking. These included careful preparation, a speaking version, liberal use of notes, a conversational manner, and use of plain English.

F. R. Jones, chairman of the College Division, presided, and introduced next M. M. Boring, General Electric Co., who spoke on "Employment of College Personnel by Industry." He emphasized the point that employers have been generally successful in judging a graduate engineer's technical ability and assigning the graduate to appropriate work. He indicated this to be true to the extent that practically all cases of failure of an engineer to get along well in his work are due to personality and human relations factors.

In the concluding address of the afternoon, W. C. Van Dyck, Caterpillar Tractor Co., dealt with "Postgraduate Training Courses in Industry." He spoke in terms of helping the graduate get oriented in his new environment and establish desirable habits of continuing personal and professional development.

In keeping with its traditions, the ASAE Annual Dinner brought the meeting to a fitting climax of good dining, good fellowship, fun, recognition, ceremony, and appreciation of the human significance of agricultural engineering. L. F. Livingston, past-president of ASAE, and manager, extension division, E. I. duPont de Nemours and Co., presided as master of ceremonies. Following introductions he called upon President Wood to present the annual awards. In doing so, Mr. Wood first referred the audience to its program announcement of Journal Paper, FEI Trophy, Student Paper, and Student Honor Awards. He then made presentations, in turn, of the John Deere Medal to Orson W. Israelsen and of the Cyrus Hall McCormick Medal to Andrey A. Potter. Each responded with brief remarks indicating keen appreciation of the honor and satisfaction with their long associations with agricultural engineers and the progress of agricultural engineering.

ASAE Meetings Calendar

August 31—September 2 — NORTH ATLANTIC SECTION, Long Island Agricultural and Technical Institute, Farmingdale, L. I., N. Y.

December 7-9—WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

June 20-23—47th ANNUAL MEETING, University of Minnesota, Minneapolis.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan

Mr. Livingston next called upon Wheeler McMillen, editor-in-chief of *Farm Journal*, for the address of the evening. Speaking on "Angels and Engineers" he emphasized the contribution made by agricultural engineers to helping whole populations rise above the bare subsistence level of living, and the importance to world peace of greatly increased agricultural production efficiency among many additional peoples in various parts of the world.

In the final business of the evening retiring President Wood turned the gavel of his office over to E. W. Tanquary, incoming president, who pledged his best efforts to the work of the Society. After pinning a "past-president's" emblem on Mr. Wood, he declared the meeting adjourned.

Technical division sessions Monday and Tuesday forenoon directed attention to some of the more immediate special interests of the four main technical fields in agricultural engineering.

Students present enjoyed a special program arranged by the National Council of ASAE Student Branches and the ASAE Committee on Student Branches. It included three regular sessions and a complimentary dinner by the Farm Equipment Institute. Following the dinner, presided over by F. P. Hanson, chairman of the FEI research committee, there were two addresses. President Wood spoke to the audience, including industry hosts as well as student guests, on "Expanding Horizons." A. E. W. Johnson, vice-president and director of engineering, International Harvester Co., told them "What the Farm Equipment Industry Expects of the Graduate Engineer." Edwin W. Tanquary, president-elect of ASAE, showed colored moving pictures on the development of a new tractor and implement hitch.

Student Branches winning FEI trophies for the year were announced at this dinner and presentation of the cups made by C. K. Beeman, chairman of the Committee on FEI Trophy Awards. Winners were the Pennsylvania Student Branch in Class A and the Ontario Student Branch in Class B.

Student meetings were presided over by Morris E. Schroeder, president, and Wesley L. Harris, vice-president of the National Council of ASAE Student Branches. Officers of the Council for the new year, elected at its Wednesday afternoon session, are, president, Lawrence D. Meyer, University of Missouri; first vice-president, Charles L. Overman, North Carolina State College; second vice-president, Richard R. Russell, University of Vermont; and secretary, Deane E. Miller, Iowa State College.

Extension materials entered in the several classes of competition sponsored by the Committee on Extension were on exhibit throughout the meeting, along with limited educational exhibits by Pittsburgh-area industries cooperating in sponsoring the meeting. Blue ribbon award winners will be reported in a separate news item.

Many members took advantage of the time provided on Tuesday evening to attend one or more specialized group meetings along the lines of their special interests. A College Division program provided a symposium on graduate instruction. The Committee on Extension and the Committee on Animal Shelter Ventilation each offered a round table. The Committee on Agricultural Processing reviewed its field and program.

In addition to the Sunday, Monday and Wednesday evening affairs which the ladies attended with their husbands, a special ladies program for their daytime entertainment included a visit to the H. J. Heinz Plant, home of the "57 varieties."

Many of those attending expressed keen satisfaction with the thoroughness and careful organization and procedure with which the Committee on Local Arrangements anticipated and cared for the comfort and pleasure of individual visitors as well as the over-all requirements of the program. The spirit of progress noted in Pittsburgh proved a most congenial environment for agricultural engineers and their annual meeting. *(News continued on page 488)*

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NEWS SECTION *(Continued from page 486)*

Organization Changes at ASAE Headquarters Office Announced

THE Council of the American Society of Agricultural Engineers announces that at the closing session of its meeting, held in conjunction with the Society's 46th annual meeting at Pittsburgh, June 14 to 17, it appointed Frank B. Lanham as the new Secretary of the Society for the ensuing year.

Mr. Lanham, who has served for the past 15 months as an Assistant Secretary, is an agricultural engineering graduate, having received his B.S. degree from Virginia Polytechnical Institute in 1935, also M.S. and Ph.D. degrees from Iowa State College in 1936 and 1952, respectively. He is a veteran of World War II and saw service with the U.S. Army in the Southwest Pacific theater, being released with the rank of lieutenant colonel.

Mr. Lanham succeeds Raymond Olney, who has served continuously as Secretary and editor and publisher of AGRICULTURAL ENGINEERING since 1921 and as Treasurer of the Society since 1922.

The Council has reappointed Mr. Olney to the office of Treasurer, and also as Publisher to have full responsibility for the publication of AGRICULTURAL ENGINEERING, the new "Agricultural Engineers' Yearbook," and other publications of the Society.

Ralph A. Palmer, who has served the Society as Assistant Secretary since 1927, except for two interruptions in the early 30's and 40's, and who is also a veteran of World War II and who was released with the rank of lieutenant colonel, will continue as Assistant Secretary with chief responsibility for the Society's personnel service.

Mrs. Hazel B. Smiley, who joined the Society headquarters staff in 1930 to become shortly thereafter Office Manager and Cashier, will continue in that position.

1952 ASAE Journal Papers Awards

PAPERS awarded honors announced during the ASAE Annual Meeting at Pittsburgh in June, for having been judged the best published in various issues of AGRICULTURAL ENGINEERING during 1952, were as follows:

"Loads Imposed on Power-take-off Shafts by Farm Implements" (February) by Merlin Hansen.

"Heat and Moisture Exchanges in Dairy Barns" (April) by H. J. Thompson and R. E. Stewart.

"Time-Travel Studies on Dairy Farms" (March) by Thayer Cleaver.

"The Kinematics of Tractor Hitches" (June) by D. C. Heitshu.

"Harvesting and Conditioning Grain for Storage" (July) by L. W. Hurlbut, G. M. Petersen, F. D. Young and E. A. Olson.

Five additional papers accorded honorable mention included:

"Engineering Phases of Dairy Barn Research" (October) by S. A. Witzel and D. W. Derber.

"Hydraulic Capacity Requirements for Control of Farm Implements" (May) by Wayne H. Worthington and J. Waldo Seiple.

"Simplified Procedure for the Measurement and Computation of Soil Permeability Below the Water Table" (May) by H. P. Johnson, R. K. Frevert and D. D. Evans.

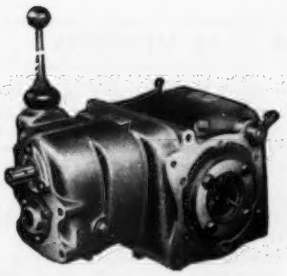
"An Experimental Harvester for Castor Seed" (December) by Milo F. Arms and Lloyd W. Hurlbut.

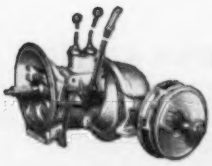
"Development of an Agricultural Airplane" (June) by Fred E. Weick.

Measures of merit used in judging the papers included authenticity, originality, timeliness, permanent value, and style. The awards were made by the Committee on Journal Paper Awards: D. D. Smith (chairman), W. J. Ridout, Jr., G. O. Schwab, A. B. Skromme, G. I. Johnson, and A. E. Powell.

(News continued on page 490)

Group at 1953 ASAE Annual Dinner at Pittsburgh. *(Left to right)* Dean A. A. Potter, recipient of the 1953 Cyrus Hall McCormick Medal; Mrs. Ivan D. Wood; Ivan D. Wood, retiring president of ASAE; Mrs. Edwin W. Tanquary; Edwin W. Tanquary, incoming president of ASAE; Mrs. O. W. Israelsen; Dr. O. W. Israelsen, recipient of the 1953 John Deere Medal





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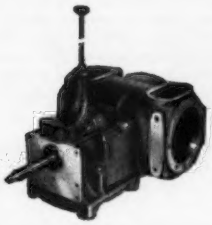

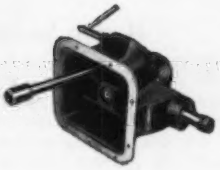

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NEWS SECTION (Continued from page 488)

Buchinger Heads Michigan Section

ACCORDING to announcement received at Society headquarters, the new 1953-54 officers of the Michigan Section of the American Society of Agricultural Engineers include W. G. Buchinger, farm service engineer, The Detroit Edison Co., as the new chairman of the Section. The list also includes the following vice-chairmen: T. J. Brevic, assistant professor of agricultural engineering, Michigan State College; W. M. Carleton, also of the agricultural engineering staff, Michigan State College, and C. W. Richey, harvesting engineer research engineering department, Dearborn Motors Corp. The new secretary of the Section is E. H. Kidder, assistant professor of agricultural engineering, Michigan State College.

The new nominating committee for the Section consists of H. F. McColly, Michigan State College; D. B. Poor, Great Lakes Steel Corp., and H. C. Wolsey, The Oliver Corp.

Tennessee Section Elects Walker

AT ITS regular spring meeting held this year in Gatlinburg, Tenn., May 22-24, the Tennessee Section of the American Society of Agricultural Engineers elected W. R. Walker, electrical development specialist, Tennessee Valley Authority, Chattanooga, Tenn., as the new section chairman. A. E. Adkins, Athens Plow Co., Athens, Tenn., was elected the new vice-chairman of the Section, and E. B. Hale, extension specialist in rural electrification, University of Tennessee, Knoxville, the new section secretary. This meeting as always was primarily a social gathering of members and their families, with a short business session. According to reports, a delightful time was had by all.

Hawaii Section Meeting Program

"ELECTRICAL Control Instruments" was the title of a talk before the Hawaii Section, American Society of Agricultural Engineers, at its meeting Monday evening, May 18. The speaker was Robert Plaus, electrical engineer, American Factors, Ltd.

Mr. Plaus approached his subject from the viewpoint that practically any physical value or condition can now be measured and controlled, or used as a means to control other values or processes. From this introduction he went on to review the essential features of simple instruments, and their combination and applications in progress toward the automatic operation of complete processes.

Warren Gibson, section chairman, announced that a discussion of land-preparation methods would be featured at the next quarterly meeting of the Section. He also reported a substantial increase in the Section membership.

Teacher Training Report Available

A REPORT on "Pre-Service and In-Service Training Programs," presented before the College Division at the ASAE Annual Meeting in Pittsburgh in June, is now available on request to the ASAE headquarters office, St. Joseph, Mich.

The Committee on Agricultural Teacher Training, College Division, ASAE, prepared the report, in collaboration with an advisory group of agricultural education specialists. It has been approved by the Executive Committee of the College Division.

Present and former committee members contributing to the development of this report are E. W. Foss, G. E. Henderson, C. N. Hinkle, A. H. Hollenberg, M. M. Jones, V. J. Morford, C. F. Albrecht (chairman), R. H. Driftmier, I. G. Morrison, A. J. Schwantes, and D. C. Sprague.

The advisory group of agricultural education specialists included David Hartzog, H. W. Kitts, D. R. McClay, T. J. Wakeman, H. B. Swanson, J. K. Coggin, J. R. Cullison, H. M. Hamlin, C. W. Hill, and S. S. Sutherland.

Hydraulics Research Program

A JOINT meeting of the Hydraulics Division of the American Society of Civil Engineers and the International Association of Hydraulic Research will be held at the University of Minnesota, Minneapolis, September 1 to 4, 1953. Subjects for presentation and discussion at the technical sessions will include basic relationships of sediment transportation by flowing water, density currents, air entrainment of flowing water, and waves, beach erosion, and hydromechanics of shore structures. Additional information concerning the conference may be obtained by writing L. A. Johnson, Saint Anthony Falls Hydraulic Laboratory, Minneapolis 14, Minn.

(News continued on page 496)

NEWS OF ASAE MEMBERS

J. B. DAVIDSON was one of five Iowa State College faculty members awarded a faculty citation at the annual Alumni Day ceremonies at Ames, June 13. The citation is for outstanding long service (more than 40 years) on the staff of the College, including achievement in proving a source of inspiration to students and leaders in the field of endeavor of the recipient. As charter-honorary member and first president of ASAE, and as teacher, administrator, and consultant in his field, his influence has contributed to the development of many younger agricultural engineers now filling highly responsible positions, to technical progress and increasing public acceptance of agricultural engineering, and to the development of sound philosophy on human objectives of agricultural engineering.

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R. W. TRULLINGER, life fellow and past-president of ASAE, chief of the Office of Experiment Stations and assistant research administrator, U.S. Department of Agriculture, received one of the Department's "distinguished service awards" at an honor awards ceremony in Washington, D.C., May 19. Ezra Taft Benson, Secretary of Agriculture, made the presentation. The citation of Mr. Trullinger read: "For vision and leadership in research administration which has been a vital force in fostering strong federal-state relationships and in achieving an efficient, well-coordinated total agricultural research program." Following the presentation, Mr. Trullinger characterized it as "a vote of confidence in our relationships with the state agricultural experiment stations" as well as a personal honor.

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DAVID A. ISLER, agricultural engineer (BPISAE), U.S. Department of Agriculture, was presented a "superior service award" of the Department at its honor awards ceremony in Washington, D.C., May 19. His citation read: "For his contribution to the development of a dual sprayer which has materially reduced the number of airplane test flights necessary to determine the proper degree of spray atomization."

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KENNETH A. FINDEN recently joined the general engineering department staff of the Green Giant Co., LeSueur, Minn. He was formerly an engineer with the Smalley Mfg. Co., Manitowoc, Wis.

• • •

E. A. JUZWIK, formerly president and chief engineer, Ezee Flow Corp., Chicago, now that that company has been acquired by Avco Mfg. Corp., will continue with this new Avco Division in the capacity of general manager.

• • •

WALDO H. KLIEVER has resigned as director of research, Minneapolis-Honeywell Regulator Co., to become vice-president and director of instrument development, Clevite-Brush Development Co., Cleveland, Ohio, a division of Clevite Corporation.

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W. C. KRUEGER, extension agricultural engineer in New Jersey, was honored May 19 with a dinner commemorating his 25 years of service to farmers of the state. The Farm Electrification Council of New Jersey arranged the dinner and presented him with a set of matched luggage. This is the second recognition of his services bestowed in recent months. In February the Co-op Interbreed Cattle Association honored him with its distinguished service award.

• • •

J. P. SCHAENZER, electro-agriculture specialist, operations division, Rural Electrification Administration, USDA, has recently been appointed chairman of the division of engineering of the graduate school of the USDA. He succeeds T. B. Chambers who has held the position for seven years. Engineering courses are offered by the school for both graduates and undergraduates in the Washington area. The current catalog lists twelve courses which supplement the engineering instruction available in the general colleges and universities in or near the District of Columbia.

• • •

WILHELM VUTZ recently severed his connection with the engineering department of the Mount Vernon Implement Company to accept the position of product design manager of the New Holland Machine Division of The Sperry Corp. at New Holland, Pa.

• • •

GEORGE E. WOMBLE was recently named product engineer of the Horn Mfg. Co., a subsidiary of Avco Mfg. Corp. at Fort Dodge, Iowa. Mr. Womble previously served in the same capacity with the New Idea Div. of the Avco organization at Coldwater, Ohio.

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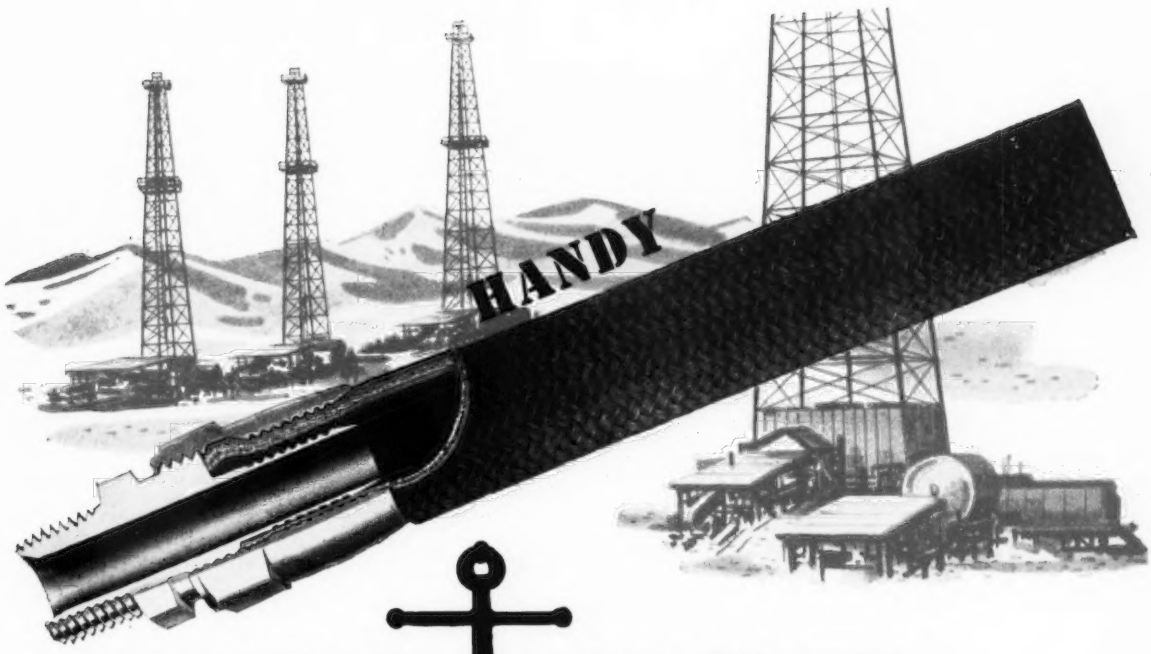
J. R. W. YOUNG, formerly head of the agricultural engineering department, University of British Columbia, is now employed as chief field test engineer of Massey-Harris Co., Ltd., and is located at the head office of the company at Toronto.



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NEW BOOKS

SAE HANDBOOK (1953 edition). Cloth, 1032 pages, 8½ x 11 inches. Illustrated and indexed. Society of Automotive Engineers (29 W. 39th St., New York 18, N. Y.).

New standards, recommended practices and reports included in this edition apply to magnetic-particle inspection, carbon and low-alloy steel investment castings for automotive requirements, surface-finish control, involute spline and serration gages and gaging, automotive and general service copper tube, hydraulic flareless tube fittings, breakaway connector, ignition coil mounting, torque requirements for spark plug installation, headlight testing machines, flywheels for overcenter clutches, diesel-fuel injection-pump mountings, diesel-fuel injection-pump mounting flange No. 5, diesel-fuel injection nozzle-holder assemblies, large-size radiator filler necks, color code for hydrodynamic-drive illustrations, performance curve sheets for hydrodynamic-drive vehicles, brake spider mountings, brake test code-dynamometer, and ride and vibration terminology.

Revisions are indicated for previously published material under the headings of SAE technical board rules and regulations, chemical compositions of SAE carbon steels, chemical compositions of SAE alloy steels, general characteristics and heat-treatments of steels, estimated physical properties of hot-rolled and cold-finished carbon steel bars, methods of determining hardenability of steels, physical requirements for bolts, capscrews, studs and nuts, cast shot and grit for peening and cleaning, bearing and bushing alloys, rubber and synthetic-rubber compounds for automotive and aeronautical applications, classifications of elastomeric compounds for automotive resilient mountings, latex foam rubbers, sponge and expanded cellular rubber products, fuel and oil hoses, automotive brake hoses, hydraulic brake fluid, crankcase oil types, transmission and axle-lubricant classification, screw threads, square and hexagon bolts and nuts, round-head bolts, plain washers, ball and roller bearings, automotive tube fittings, hydraulic flanged tube, pipe, and hose connections — 4-bolt split-flange type, hydraulic hose and fittings, circuit breakers, storage batteries, starting-motor and generator curves, magneto mountings, 6 and 12-volt cigar lighter switch bases, lamp bulbs and bases, sealed beam headlamp units for motor vehicles, electric supplementary driving lamps, electric supplementary passing lamps, license-plate lamps, turn-signal units, turn-signal operating units, spot lamps, back-up lamps, reflex reflectors, school-bus warning-signal lamps, electric emergency lanterns, liquid-burning emergency flares, lamps for aircraft lighting, lamps for airdrome and airway lighting, engine flywheel housings, brake linings, rivets for brake linings and bolts for brake blocks, agricultural tractor drawbars, yardage ratings, and air-cleaner test code.

1953 BUYERS GUIDE. Paper, 432 pages, 8¼ x 11 in. Indexed. Farm Implement News (Chicago 5, Ill.). Published as Section 2, *Farm Implement News*, April 25, 1953. Special issue price not stated. Farm equipment classified by types and crops; complete lines of farm equipment manufacturers, listed geographically; farm equipment manufacturers listed alphabetically; shop equipment and supplies, tractor parts and accessories; wholesalers and facilities offered, listed geographically; and index of farm equipment classifications.

NEW BULLETINS

Insolation: A Primary Factor in Evaporation from a Free Water Surface in Michigan, by George A. Crabb, Jr. Reprint from the Quarterly Bulletin (vol. 35, no. 2, November, 1952) of the Michigan Agricultural Experiment Station (East Lansing). A report of research showing close correlation between insolation and evaporation, as an aid in determining irrigation water requirements.

Brooding Pigs and Lambs with Infrared Lamps, by C. K. Kline and I. P. Blauser. F. E. Circular 2, Ohio Farm Electrification Council and Agricultural Extension Service (Columbus, Jan. 1952). Mimeographed for leadership training on farm practice recommendations. Scheduled for reissue and wider distribution in multilith form in 1953.

A Guide for Inspecting Electrical Installations on Farms. Ohio Farm Electrification Council in cooperation with the Agricultural Extension Service and Rural Fire Safety Committee (Columbus). Mimeographed introductory material and check list of items to be inspected under the headings of general information, service entrance, fuses and circuit breakers, wiring, grounding, motors, lighting, equipment and appliances, and cords.

Electricity—How Much? What For? by Roy M. Gilcrest. North Dakota Agricultural Experiment Station (Fargo) Bulletin 379 (Oct. 1952). A study of electrification in an area where it has developed rapidly in the past 8 years.

Electric House Heating, Rural Electrification Administration Bulletin 142-1 (Nov. 1952), U.S. Department of Agriculture (Washington 25, D.C.). Elements of heating, types of equipment, and installations, for persons interested in electric heating of private residences.

Soil-Moisture Measurement with the Fiberglass Instrument. Occasional Paper 128 (February, 1953), Southern Forest Experiment Station (New Orleans), U.S. Department of Agriculture. A composite of five related technical papers on various phases of the subject, based on experience with a project involving 210 fiberglass units installed near Vicksburg, Miss.

Importance of Secondary Flow in Guide Vane Bends, by Edward Silberman. Technical Paper No. 14, Series B (January, 1953) St. Anthony Falls (Minn.) Hydraulic Laboratory. Limited distribution of an analysis of flow, showing a secondary flow contributing materially to head loss.

Some Developments in Corn Spraying Equipment Applicable in the Everglades, by John W. Randolph and Warren N. Stoner. Contribution from the Everglades Experiment Station (Belle Glade, Fla.), reprinted from the Proceedings of the Florida State Horticultural Society, 1952. Brief information on spraying machines in commercial use, an experimental sprayer, and some mechanical factors affecting coverage.

A New L-Shaped Fence Staple, by E. George Stern, Virginia Engineering Experiment Station (Blacksburg). Popular-style leaflet presenting the substance of information covered in technical form in VPI Wood Research Laboratory Bulletin No. 11.

V Belts for Farm Electrical Motors, by Wm. H. Knight and J. W. Martin. University of Idaho (Moscow) Farm Electrification Leaflet No. 21 (April, 1953). A basic guide covering pulley and belt sizes, belt selection, applications, and installation.

Aid Distribution in Several Central Pennsylvania Hay Driers, by Elwood F. Olver. Pennsylvania Agricultural Experiment Station (State College) Progress Report No. 101 (April, 1953). Observations on performance of actual installations suggesting desirable combinations of equipment and use practices.

Electric Pig Brooders, by O. F. Goen and A. M. Pettis. Florida Agricultural Extension Service (Gainesville) Circular 110 (November, 1952). How to build and use brooders using regular or infrared electric bulbs as heat sources.

Electricity Made Easy, by A. M. Pettis. Florida Agricultural Extension Service (Gainesville) Circular 112 (January, 1953). Fifteen suggested demonstrations and 20 problems with answers for beginning vo-ag work.

An Electric Pig Brooder, by A. M. Pettis and J. Clyde Driggers. Florida Agricultural Extension Service (Gainesville) Circular 113 (February, 1953). Construction and use of a heat-lamp brooder adapted to Florida conditions.

Seasoning Lumber, by O. M. Davenport, Circular 501, Kentucky Agricultural Extension Service (Lexington). Brief general instructions, piling techniques, and related information.

Selecting Farm Electric Motors, Controls, and Drives. Compiled by Robert H. Brown and G. E. Henderson. Southern Association of Agricultural Engineering and Vocational Agriculture (Agricultural Engineering Department, University of Georgia, Athens). Vocational teaching material edited to junior high school reading level. Covers motor size, type, features, accessories, controls, and drives. Includes tables on farm machine power requirements. Published through the cooperation of the General Electric Co. Bulletin and related film strip available at prices according to quantity.

Irrigating Small Acreages, by John R. Davis. Michigan State College (East Lansing), Extension Bulletin 320 (May, 1953). A 31-page bulletin designed for the home gardener and small-acreage truckcrop gardener. It discusses the fundamentals of irrigation; how much water to apply, how often, crops and soils. Also discussed are the use of the present water supply, how to select the proper size pipe and sprinklers, and fitting equipment to a small area. Other aspects of irrigation such as water supply, fertilization, frost control and benefits are mentioned.

Sprayer and Duster Manual. National Sprayer and Duster Ass'n. (4300 Board of Trade Bldg.), Chicago 4, Ill. $1.00. This brings together in 40 8½ x 11 pages, information on chemicals and application equipment which will help users and dealers to be well informed on the subject, even though progress in this field in the past decade has been revolutionary. Covers use of sprayers and dusters in homes and gardens on farm and ranches, in industry, institutions, public buildings, and other fields; use for plant disease, insect and weed control; importance of correct timing, proper chemicals and proper equipment; types of equipment; accessories; proper operation; care and maintenance; and related useful information.

(Continued on page 504)

LOW-COST Earth-Moving Specialist

Handles Unlimited Jobs on Limited Budgets

Allis-Chalmers Model D

low-cost motor grader with TANDEM DRIVE and other *big grader* features

Weight — 8,800 lb.
Tubular Frame
ROLL-AWAY Moldboard
Power Hydraulic Controls
Rear-Engine Design
High Arch-Type Front Axle
Drop-Down Transmission
Full Visibility

Optional:
Leaning Front Wheels
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THE new Allis-Chalmers Model D Motor Grader gives the kind of earth-moving advantages that only a full-fledged, tandem drive motor grader can give — and brings this performance within easy reach of limited budgets. Rolls big loads fast, makes smooth water channels and terrace ridges, maneuvers easily, travels quickly from one job to another, yet it costs only ⅓ as much as large motor graders!

This grader also builds and maintains farm roads, handles ditching and sloping . . . with bucket attachment, loads material. And it's economical to maintain as well as to own. Any mechanic can service the 40 hp. gasoline engine. Parts are carried by all A-C tractor dealers.

Write for free catalogs or ask your Allis-Chalmers industrial tractor dealer to show you how the Model D can stretch conservation and road maintenance dollars.

Level it, slope it, ditch it, pile it — *or load it.* When it comes to moving dirt at low cost, the Model D is your machine. Rear-mounted hydraulic shovel with ⅝ cu. yd. bucket adds still further to its usefulness. Saves time, men and equipment on loading and stockpiling jobs . . . ideal for filling small gullies and ditches on terracing work.

Roll-Away is an Allis-Chalmers trademark.

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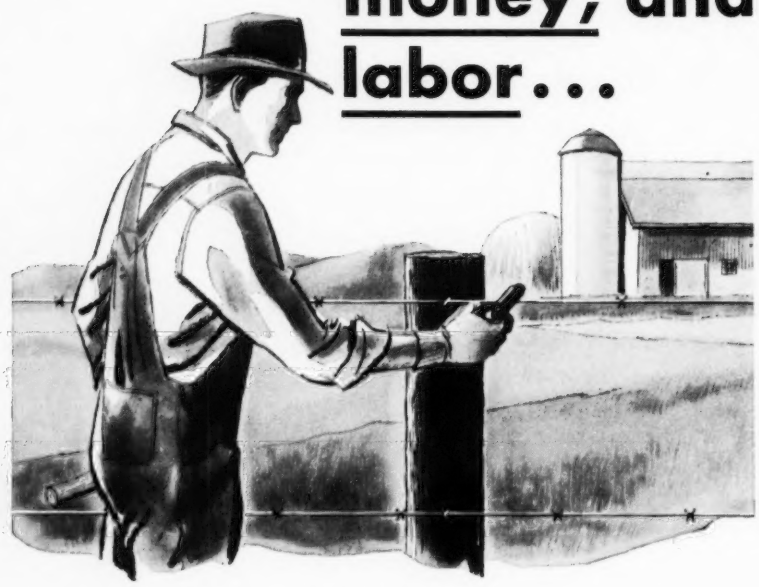
TRACTOR DIVISION — MILWAUKEE 1, U. S. A.

Save the farmer time, money, and labor...



Recommend pressure-creosoted fence posts

● When you recommend pressure-creosoted fence posts, you're doing the farmer a *real* service. Since pressure-creosoted posts last 3 to 5 times longer than most types of untreated posts, repair and replacement costs are reduced to the barest minimum. Money, time, and labor, normally spent repairing or replacing deteriorated posts, can be devoted to more important jobs.

Pressure-creosoted fence posts are unharmed by repeated grass fires. Flaming stops, leaving only minor surface char, when the grass fire moves on.

For complete information about creosote, write to Koppers Co., Inc., Tar Products Division, Pittsburgh 19, Pennsylvania.

KOPPERS COMPANY, INC., PITTSBURGH 19, PENNSYLVANIA

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Pittsburgh, Pennsylvania
Koppers Building

All Standard Specifications

KOPPERS **CREOSOTE**

The Performance-Proved Wood Preservative

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

AGIDIUS, DONALD V. A.—Student, Oregon State College. (Mail) 1514 Trevitt St., The Dalles, Ore.

ASHER, DON L., JR.—Student, University of Florida, Gainesville, Fla. (Mail) Beta Theta Pi House.

BENNISON, ERNEST W. — Office engineer, Edward E. Johnson, Inc., 2304 Long Ave., St. Paul 14, Minn.

BEPPLER, DAVID C.—Student, University of Maine. (Mail) 218 Park St., Montclair, New Jersey

BRANDT, MAURICE W.—Graduate assistant, Michigan State College. (Mail) 1240 E. Leonard, Grand Rapids, Mich.

BROWN, ROBERT L.—Student, University of Maine. (Mail) Brooks, Me.

BURCHFIELD, GLENN L. — Salesman, Oregon Tractor Co., 9 Depot St., LaGrande, Ore.

BURKE, JOHN T.—Farm machinery salesman, Orange State Motor Co. (Mail) 2412 Burlington Ave., St. Petersburg, Fla.

CHEATUM, LEO G.—Project engineer, John Deere Ottumwa Works, Ottumwa, Iowa. (Mail) 16 Silverwood Drive

CHENOWETH, JOHN W.—Student engineer, John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 708 W. 3rd St.

CHURCHILL, WILLIAM D.—Field manager, Cargill, Inc., Grinnell, Iowa

CLEMENTS, WAYNE W.—Student, Michigan State College. (Mail) 2515 Textile Road, Saline, Mich.

FORD, JAMES K., JR.—Student, University of Georgia. (Mail) 279 Foust St., N.W., Atlanta, Ga.

FUTCH, ALFRED E.—Field representative, Gulf Fertilizer Co., Box 128, Avon Park, Florida

GEIBERGER, DONALD E.—Student, University of California. (Mail) 1118 Cavanaugh Way, Sacramento, Calif.

GENTRY, DONALD—Student, University of Georgia. (Mail) RR 1, Blakely, Ga.

HALL, JOHN C. — Electrical development representative, Tennessee Valley Authority. (Mail) 717 Church St., Nashville, Tenn.

HARRIS, WESLEY L.—Student, University of Georgia. (Mail) Taylorsville, Ga.

HOWLETT, FRANCIS W. — Cartographic-photogrammetric aid, U.S. Navy Hydrographic Office. (Mail) Apt. 2, 7805 Atwood St., Washington 28, D.C.

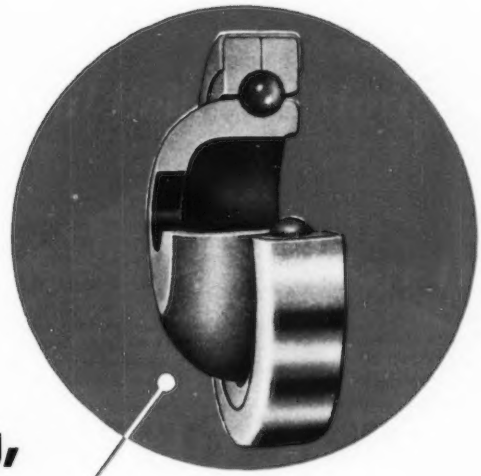
HUNTER, JAMES H.—2nd Lt., U.S. Army. (Mail) Route 1, Caribou, Me.

JENSEN, WILLIAM C.—Student, University of California. (Mail) 6119 Canning St., Oakland 9, Calif.

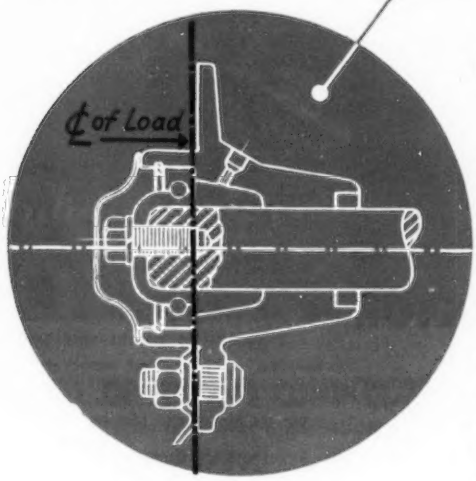
JOHNSON, LYNN F.—Student, University of Idaho. (Mail) Route 1, Preston, Idaho

JOHNSON, ROBERT W.—Draftsman, J. I. Case Co., Racine, Wis. (Mail) 3112 13th Street

(Continued on page 496)



This BCA wheel bearing, DESIGNED SPECIFICALLY FOR FARM EQUIPMENT, cuts both assembly and maintenance costs



Pat. Applied for

BCA designed this economical anti-friction bearing to meet the needs of both manufacturer and user of farm equipment.

This time-saving *package unit* means simple, low-cost mounting on the axle shaft. What's more, the shaft need not be machined because the eccentric position of the holding screw prevents rotation of the inner ring.

This BCA wheel bearing takes both radial and thrust loads, with sufficient capacity for practically any piece of farm equipment. Used in connection with a sliding bearing, which merely acts to "steady" tilting loads, its simple, rugged construction eliminates many of the farmer's maintenance headaches and cuts field-servicing to a minimum.

BCA has made many contributions to the solution of the bearings problems peculiar to farm equipment. Perhaps we can solve *your* bearings problems.

BCA *radial, thrust, angular-contact Ball Bearings*

BEARINGS COMPANY OF AMERICA

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Applicants for Membership

(Continued from page 494)

KING, R. T.—Farm service supervisor, Texas Power & Light Co., Fidelity Union Life Bldg., Dallas, Texas

LAMBERT, GERALD E.—Student, University of California, Davis, Calif. (Mail) Apt. D-12 Aggie Villa

LIGHT, ROBERT G.—Student, University of Maine. (Mail) Ghent, N. Y.

LORING, MALCOLM S.—Agricultural engineer, Portland Cement Assn. (Mail) P.O. Box 66, Ithaca, N. Y.

MAINEY, JOHN K.—U.S. Air Force. (Mail) Mazon, Ill.

MCLAREN, C. L.—Instructor, sales training div., Caterpillar Tractor Co., Peoria, Ill.

MENDOZA, TEOFILO M.—Assistant soil technologist, Bureau of Soil Conservation. (Mail) 645 "C" St., Davis, Calif.

MURRAY, CHARLES D.—Test engineer, The Coolerator Co., Duluth, Minn. (Mail) 710 N. 23rd Ave. W.

PALMER, ROBERT S. — Agricultural Engineering Dept., University of New Hampshire, Durham, N. H.

PLACKE, FRED O.—Student, A & M College of Texas. (Mail) Box 53, Giddings, Tex.

REED, DALE D.—Training program, John Deere Waterloo Tractor Works. (Mail) RFD 1, Veedersburg, Ind.

ROBINS, LAWRENCE E.—Farmer, Box 133, Cimarron, Kans.

ROHALY, WILLIAM E.—Student, University of Illinois. (Mail) 9232 S. Avalon Ave., Chicago 19, Ill.

RUMMEL, CARL G. — Student, Michigan State College. (Mail) Frankenmuth, Mich.

SANFORD, BENJAMIN F.—Agricultural engineer, United States Sugar Corp., Clewiston, Fla.

SCHEFFLER, DAVID R. — Student, Purdue University. (Mail) RR 4, Shelbyville, Ind.

SEALE, WILLIAM L.—Draftsman, J. I. Case Co., PO Box 151, Anniston, Ala.

SLETTEN, WILLIS H. — Graduate research assistant, agricultural engineering dept., North Dakota Agricultural College, Fargo, N. D. (Mail) A-12 North Court

SMITH, CLAUDE H.—Director of rural development, Florida Power & Light Co. (Mail) PO Box 521, Ormond Beach, Fla.

THEDE, VERNON W. — Sales engineer, French & Hecht Div., Kelsey-Hayes Wheel Co., Davenport, Iowa

VOEGELI, WENDELIN L.—Assistant director of engineering, Allis-Chalmers Mfg. Co., Milwaukee, Wis. (Mail) RR 4, Box 618F

WAWRZYNIAK, ROBERT E.—Salesman, Martin Steel Products Co. (Mail) RR 6, Box 121, South Bend, Ind.

WEILAND, GERALD E.—Student. (Mail) 41 Santa Rosa Pk., SanLuis Obispo, Calif.

WEST, JAMES R.—Senior engineer, New Holland Machine Div., The Sperry Corp., New Holland, Pa. (Mail) 208 W. Conestoga St.

WIGGINS, BENJAMIN E.—(SCS), USDA, Sanford, Fla. (Mail) Route 1, Box 302

WISER, EDWARD H. — Student, Iowa State College. (Mail) Macedonia, Clarkesville, Georgia

WRATTEN, FINIS T.—Associate agricultural engineer, (REA), USDA, Agricultural Engineering Bldg., Louisiana State University, Baton Rouge, La.

WYLIE, CHARLES A., JR. — Student, Ohio State University. (Mail) Athalia, Ohio

ZOOK, DONALD G. — Trainee, Caterpillar Tractor Co. (Mail) Athens, Ill.

TRANSFER OF MEMBERSHIP GRADE

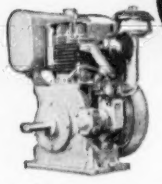
RHODES, A. J. — Rural service consultant, Louisiana Power & Light Co., 142 Delaronde St., New Orleans 14, La. (Associate Member to Member)

Power TO FIT THE JOB

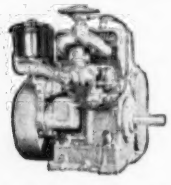
WISCONSIN-POWERED

Power TO FIT THE MACHINE

SHAW Du-All TRACTOR



3 to 9 hp. single-cyl. models.



7 to 14.5 hp. 2-cyl. models.

15 to 36 hp. V-type 4-cyl. models.

Quickly moving rocks, sand, earth, grain, manure and many other materials are only a few of the tasks handled by the Shaw Du-All Tractor with hydraulically controlled front end loader. Also, the Du-All easily wades into such jobs as cultivating, mowing and spraying . . . even pulls a 14" bottom plow in most soils. Its automotive-type transmission and differential gears are machine cut, heat-treated and run in oil for longest life. And power is provided by a model TF 2-cylinder, 14.5 hp. Wisconsin Heavy-Duty Air-Cooled Engine. Tractor builder is Shaw Mfg. Co., Galesburg, Kans.

Actually, the choice of a Wisconsin Engine is a logical one for this manufacturer, just as it is for over 500 other equipment builders. Such features as thrust-absorbing tapered roller bearings at both ends of the crankshaft, fool-proof air-cooling, rugged construction and an outside-mounted magneto equipped with impulse coupling for quick, easy starting . . . all add up to *overall equipment efficiency, trouble-free performance.*

Complete your power equipment file with latest specifications about all 4-cycle single-cylinder, 2-cylinder and V-type 4-cylinder models, 3 to 36 hp.

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WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

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NEWS SECTION

(Continued from page 490)

Morse Addresses Washington Section

TRUE D. MORSE, Under Secretary of Agriculture, was guest speaker at the May 8 meeting of the Washington (D.C.) Section, American Society of Agricultural Engineers.

Speaking on economic aspects of agricultural engineering, he indicated that shortages of equipment and materials in recent years had resulted in some substandard engineering in agriculture. Continuing, he expressed a conviction that we are now entering an era in which agricultural engineering will be of paramount importance. He looked for continuing encouragement for farmers to increase their production efficiency, with agricultural engineering a primary means by which it can be realized. Mr. Morse stressed the point that agricultural engineering must aim at sound, long-range approaches to agricultural progress, and that economic considerations will become increasingly important factors in agricultural engineering.

The occasion was the regular monthly luncheon meeting of the Section, with 53 members and guests present.

Manhattan Agricultural Belting—More Dependable

Manhattan Agricultural Belting—More Dependable

UNDER ALL OPERATING CONDITIONS, and on all types of power applications, Manhattan Agricultural Belts have won the confidence of Farm Equipment Manufacturers. The engineered features of strength, flexibility, and long-life which are built into these belts account for their consistently uniform performance and their day-in, day-out dependability on the job.

Manhattan's 60 years of pioneering research and development has produced the most reliable and economical agricultural rubber products in the field today. Designed to meet rigid manufacturers' specifications, Manhattan Agricultural Belts are continually contributing to the success of farm equipment by making power drives as nearly foolproof and trouble-free as possible.

Manhattan is always ready and eager to help specify the proper belt for your needs and to work with your engineers on the design of new power transmission drives. Call us at any time. There is no obligation.

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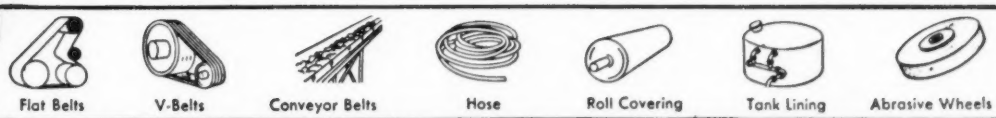
MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.



Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings
Asbestos Textiles • Teflon Products • Packings • Sintered Metal Parts • Bowling Balls

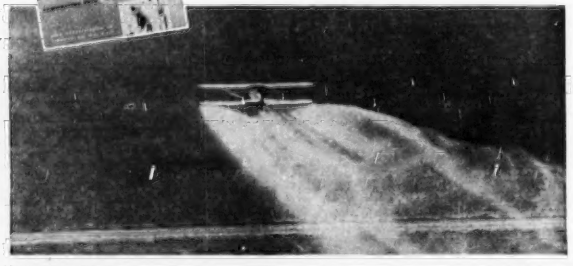
It's important in crop spraying to get thorough coverage of the crop. That calls for reliable equipment like the Aero Mist Master which depends on STOW flexible shafting to transmit power from the accessory gear box to the pump which delivers the insecticide to the spray nozzles beneath the wing.

According to Mabry I. Anderson, of Mississippi Valley Aircraft Service, manufacturers of the Aero Mist Spray System, "Your shafts have never failed—even though they've already given us thousands of hours of *trouble free* service".

Consider STOW flexible shafting for your next Power Drive or Remote Control application. Our engineering department will be happy to work with you. No obligation, of course.

◀ ***Write today*** for your free copy of Bulletin 525 containing complete engineering data on STOW flexible shafting.

See us in SWEET'S CATALOG



STOW MANUFACTURING CO.
39 SHEAR ST. BINGHAMTON, N.Y.

Land Leveling

(Continued from page 482)

nothing, and progress to more refined land preparation for irrigation can be expected after a few years.

Costs and Profits. The cost of land preparation is entirely dependent on the individual job to be done. In general, grading with heavy equipment is figured roughly at 15c per cu yd. This cost is considerably reduced when the farmer uses smaller equipment with his own tractor. Depending on the quality of the land, the value of the crop to be grown, and the availability of a sure market, considerable expense for land preparation can be justified. Leveling costs of $50 to $100 per acre are numerous, and with farm labor becoming increasingly scarce in many instances, the farmer cannot afford not to prepare his land properly. When two men can irrigate a field in 24 hr time, which before leveling required the same two men a 2-week period to water, there is no question as to the practicability of this investment.

Drainage, Dry Land and Permanent Pastures. Related to the subject of land preparation for irrigation, is the matter of land preparation for drainage in the heavier rainfall areas, for improvement of permanent pastures, and for dry-land farming. Through the use of land-leveling equipment in heavy rainfall areas, it is possible to secure better drainage by eliminating the swales and potholes. Moisture is conserved for dry periods, erosion control is maintained by checking gully erosion, and more efficient cultivating and mechanical harvesting is possible on smooth level fields.

For dry-land wheat crops, smooth fields are extremely important from several standpoints. As in the case of the humid areas, the operation of all farm machinery on smooth fields is considerably faster and more efficient, and gully erosion can be controlled by smoothing out the small washings that start each year. A superior dry-land seedbed which has been prepared with the right kind of leveling equipment, will permit maximum germination of all seed planted and has shown increases of wheat yields by as much as 20 per cent.

Many ranchers have testified that leveling their permanent pasture ground is a profitable investment. The old pastures should be plowed up and the surfaces smoothed to eliminate potholes. This will result in a firm, level and well-packed seedbed necessary for the establishment of pasture grasses and uniform germination and emergence. Actually a better stand can be obtained with less seed. Mowing, raking, harvesting or baling will be faster and more efficient. Certainly if the pasture is to be irrigated, a level surface is vital to insure complete water coverage. Even in orchards the leveler has important use for irrigation and to prepare the surface for mechanical harvesting.

Almost every soil conservation practice, including contour planting, terracing, providing surface drainage, construction of grass waterways, and the elimination of gully erosion, can be accomplished more easily and at greater savings by proper land preparation through leveling. It is not suggested that land leveling is a cure-all for all soil and water problems facing the farmer and technician. It is contended, however, that farm programs leading to maximum production and conservation of land resources will be greatly supplemented by farming on smooth fields.

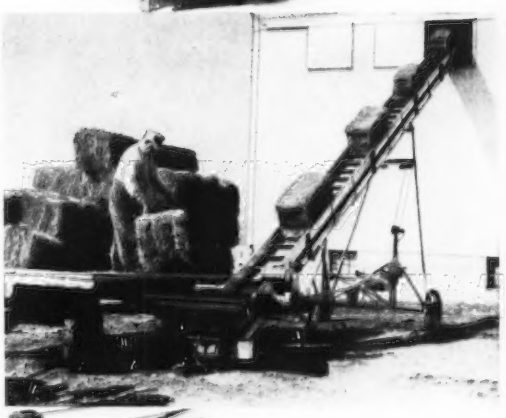
"No other farm elevator does SO MANY jobs . . . SO WELL!"

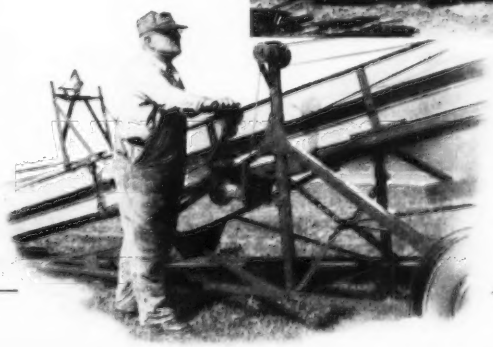
NEW IDEA
all purpose
ELEVATOR

Here is an elevator of advanced design that gives the farmer greater durability and outstanding performance. It's suspension trussed and reinforced. Available with short truck up to 36 ft. and long truck up to 50 ft. Can be furnished with triangular hopper or large tilting hopper with 7 ft. drop gate. A real man saver the year 'round. Write us for its many other outstanding features.

Handles anything!

The big capacity trough, 17½ inches wide inside, has high sides to eliminate spilling or falling. It handles all kinds of loads with ease: ear corn, small grain, bales, etc.





So easy to use . . .

. . . easy to move and transport from one job to another—easy to raise or lower. No pawls or locks to get out of order. When raised to proper height, an angle bar prevents crank from turning. It just can't let go.

NEW IDEA
FARM EQUIPMENT COMPANY
Division AVCO Distributing Corporation
COLDWATER, OHIO, U. S. A.

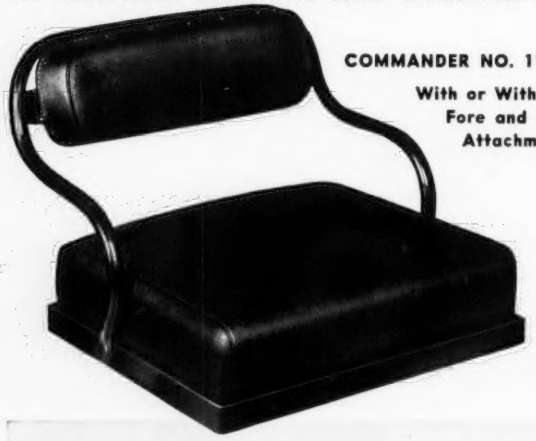
For ROUGH TOUGH HARD going

Milsco MILWAUKEE

SENIOR CONTOUR NO. 1893

Cushion Seats

MILSCO BRINGS YOU NEWEST ADVANTAGES IN SEATING COMFORT AND DURABILITY



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With or Without Fore and Aft Attachment

Improved driver-comfort is one of today's major engineering objectives . . . and Milsco can help you to step up the man-work-factor of your equipment with job-fitted cushion seating. Milsco Cushion Seats are the developments of years of experience in designing and manufacturing heavy duty cushion seats for all types of mobile equipment. Our field studies of enduring cushioning materials and contour body support may prove of important value to you. Write us about your seating problem now.

Sold Only to Original Equipment Manufacturers

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MILSCO MANUFACTURING CO.

2732 N. 33rd ST., MILWAUKEE 45, WIS.

NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

Booklets on Use of Sun's Heat

Libbey-Owens-Ford Glass Co., Toledo, Ohio, will send on request copies of booklets just issued on how to plan windows to make farm buildings warmer and dryer in winter and yet keep them cooler in summer. They explain how the solar principle of heat, used for years in home construction, can be used in the design of dairy barns, poultry buildings and hog and sheep pens.

New Model Farm Tractor

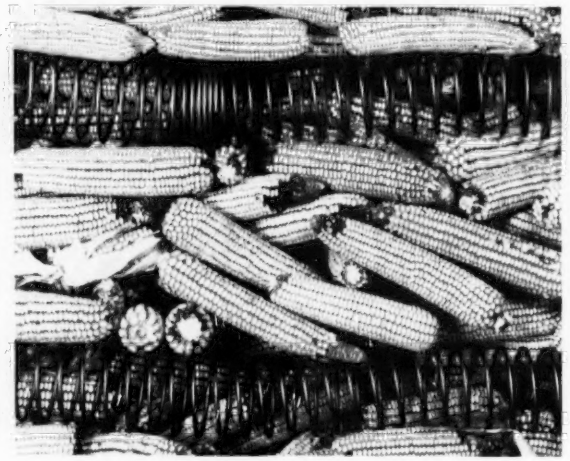
J. I. Case Co., Racine, Wis., announces the new model "SC" tractor capable of producing 15 percent more power with improved fuel economy. Dual-valve constant hydraulic control, operated by twin levers, is regular equipment and gives one-hand operation of two hydraulic cylinders — both together, or separately — for such applications as loaders

New J. I. Case Model "SC" tractor

with hydraulic tilt as well as lift. The tractor has a foot clutch which leaves both hands free for use of hydraulic control and steering at the same time. All Eagle-hitch rear-mounted implements can be used with it, including the breakaway contour plow. A new comfort seat has torsional rubber suspension that absorbs jolts and minimizes pitching and bouncing from rough ground. A constant-running power take-off has its own clutch, completely independent of the traction clutch and gear shift, so that PTO machines can be brought up to speed before the tractor moves and kept running during travel stops and starts.

Sectional Corn Ventilating Tube

American Steel and Wire Division, United States Steel Corp., Cleveland, Ohio, has announced a new product, known as Flexi-Vent, a sectional ventilating tube to permit passage of air in corn cribs. This



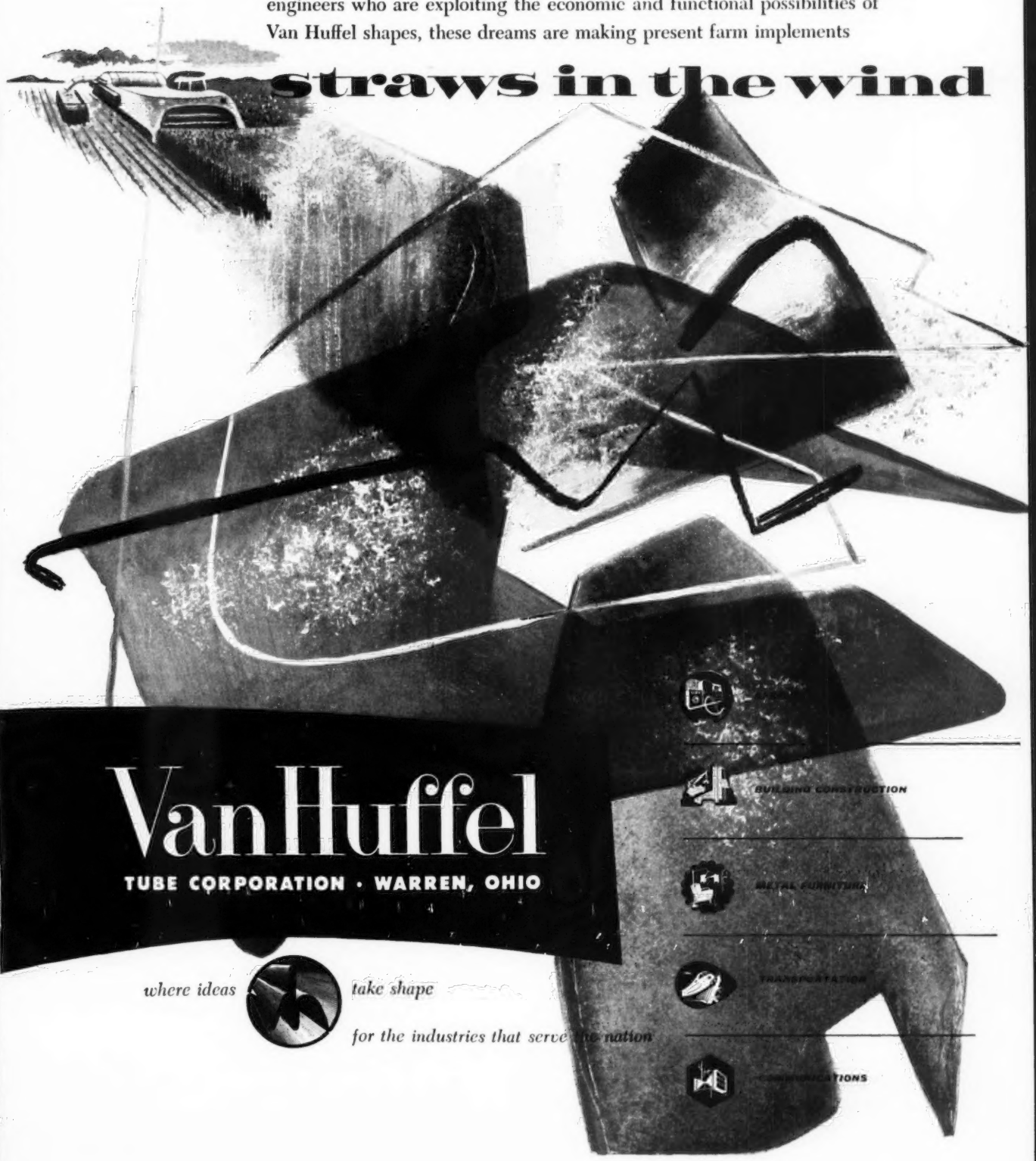
Flexi-Vent ventilating tube as used in a corn crib

product is a steel spring about 3 in in diameter and 3½ ft long. As a crib is filled the springs are placed in position along with the corn and provide additional air space and natural ventilation. Sections of Flexi-Vent may be attached together, end to end, to form conduits of any desired length, without use of any additional attachment.

(*Continued on page 502*)

Only an imaginative "let's look ahead" attitude toward new materials and production techniques made possible today's amazing farming methods and equipment. For example, take some of the "impossible" shapes we cold form daily from all kinds of metals, in any lengths and for an ever growing list of farm applications. Yesterday, these applications were but drawing board dreams. Today, thanks to alert design engineers who are exploiting the economic and functional possibilities of Van Huffel shapes, these dreams are making present farm implements

straws in the wind



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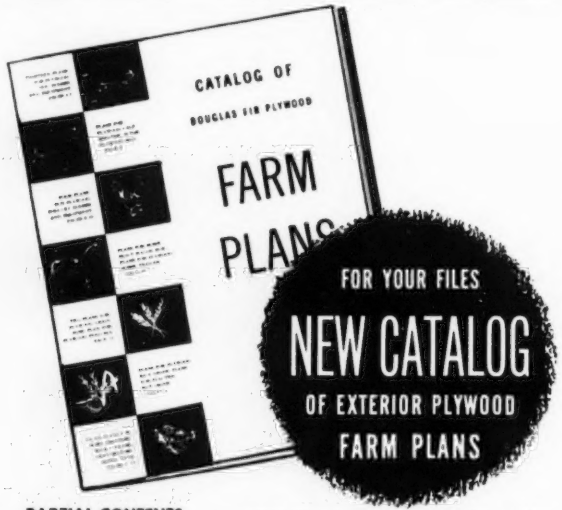

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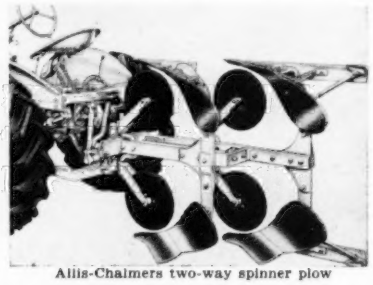
NEWS FROM ADVERTISERS

(Continued from page 500)

New Two-Way Spinner Plow

Allis-Chalmers Manufacturing Co., Tractor Division, Milwaukee, Wis., announces introduction of a new two-way, two-furrow mounted spinner-type plow for its Model CA farm tractor. A simple trip release permits the operator to spin the plow bottoms quickly to alternate positions without leaving his seat. Shorter turns and narrower headlands are possible through the close coupling of the plow which, wih a free-swing forward hich, operates like a pull-behind implement. The plow has beams and stress points built of special, heat-treated steel. It is available in either 12 or 14-in sizes.



Allis-Chalmers two-way spinner plow

New 6 or 7-Foot Combine

John Deere, Moline, Ill., announces the new No. 25 combine with 6 or 7-ft cut, as successor to the No. 12-A. The machine provides full-width, straight-through handling of grain and straw; new quick-change cylinder-speed control; new open-bar grate with snap-in inserts; new windrowed spreader which distributes crops evenly over full width of platform; new all-steel straw rack; new non-piling cleaning shoe; stronger frame and hitch, and better flotation for soft or muddy fields.

The new John Deere 25 combine

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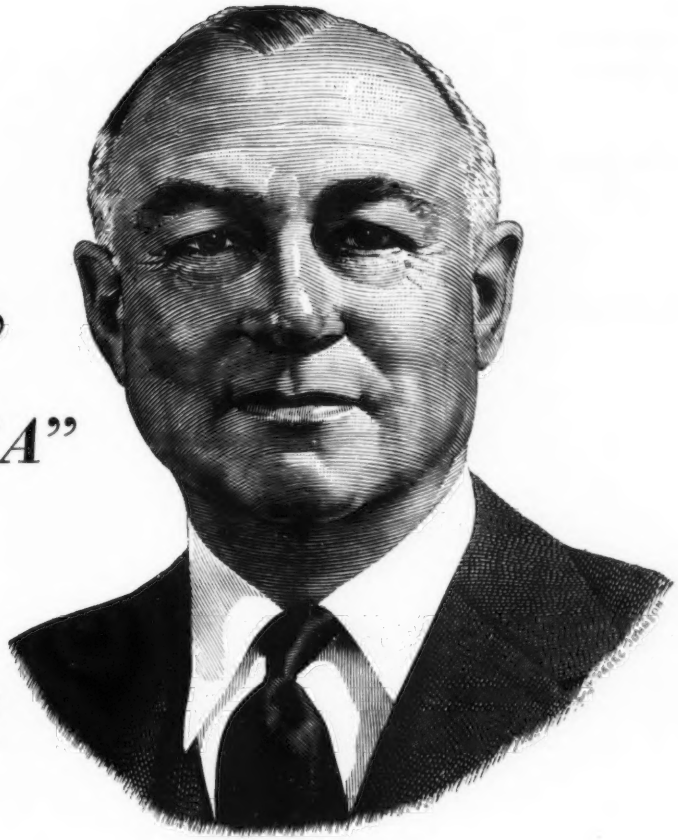
"...Well done, AMERICA"



GEORGE M. HUMPHREY
Secretary of the Treasury

"Few things in America contribute more importantly to national security than the Payroll Savings Plan—the vehicle through which millions of employed men and women build security, counteract inflation and create a reserve of future purchasing power by their monthly investment in U. S. Savings Bonds. Credit for this outstanding influence in our lives is due largely to a team that is typically American... far-sighted business executives who have made the Payroll Savings Plan available to the employees of 45,000 companies... 8,000,000 Payroll Savers... publishers of more than 500 business magazines and the management of the other advertising media who contribute generously of their space and time... the Advertising Council and advertising agencies who give freely of their skills. To these and to all who have a part in building the Payroll Savings Plan, the U. S. Treasury Department welcomes this opportunity to say, "Well done, America."

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• cash sales of Savings Bonds, all series, during the first four months of 1953 totaled $1,741,273,000—22% above those of the first four months of 1952.

• of the approximately $6.7 billion E Bonds which had come due up to the end of April, 1953, $5.1 billion, or 75% were retained by their owners beyond maturity.

• every month, nearly 3,000,000 Payroll Savers purchase about $160,000,000 in Series E Bonds.

For assistance in installing a Payroll Savings Plan, or building participation in an existing Plan, write to Savings Bond Division, U. S. Treasury Department, Suite 700, Washington Building, Washington, D. C.

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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN — MARCH—O-99-509. MAY—O-140-516, 164-517, 182-518, 190-519. JUNE—O-206-521, 208-522, 209-523, 147-524.

POSITIONS WANTED—JANUARY—W-827-152, 884-154, 896-157. FEBRUARY—W-915-162, 21-5, 19-6, 26-7, 27-8. MARCH—W-29-9, 56-10, 79-15, 85-16, 68-17. APRIL—W-64-19, 80-20, 134-21. MAY—W-120-23, 109-25, 162-26, 163-27, 151-28, 169-29, 192-30, 193-31, 196-32. JUNE—W-178-33, 204-34, 205-35, 200-36, 203-37, 210-38, 215-39, 220-40.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER (assistant professor), to teach farm power, field machinery, structures, soil and water, and utilities. Each course offered every other year. Land grant university in Northeast. BS and MS deg in agricultural engineering, or equivalent. Farm background and teaching, extension, or commercial experience desirable. Usual personal qualifications for college teaching. Opportunity for advancement normal for academic employment. Salary, up to $5000, depending on qualifications. O-240-525

EXTENSION AGRICULTURAL ENGINEER with a rapidly growing New England University. Prefer farm background, some teaching or extension experience, and MS deg. BS deg in agricultural engineering may be acceptable if other qualifications are good. Age 25-30. Good retirement system provided. Opportunity for advanced study. Rank and salary will depend upon qualifications. O-254-526

AGRICULTURAL ENGINEER for technical promotion and contact work in farm safety with commercial organizations, farm groups, agricultural leaders, college personnel and others. Farm background and some writing ability desirable. Extensive travel, headquarters Chicago. Starting salary $4500 to $5000. Excelent opportunity for young man. O-255-527

AGRICULTURAL ENGINEER for design, development and promotion work. Must be an "idea man" with knowledge of design as applied to irrigation structures and equipment. Prefer BS deg in agricultural engineering, or equivalent. Experience in design and manufacture of light metal products, or in irrigation engineering desirable. Excellent opportunity. Success in design and development of new products will lead to opportunity to follow through on market development and sales planning. Excellent employee benefits program. Salary open. O-270-528

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER available for design, development, research, sales or service in power and machinery or soil and water field with industry or public service. Northeast location preferred. BS deg in agricultural engineering, 1949, University of Nebraska. BS deg in general agriculture, 1947, Rutgers University. Farm background. Agricultural engineer with SCS 4 years. War enlisted service in Army Air Force 3 years. Age 30. Married. No disability. Available on reasonable notice. Salary open. W-231-41

EXTENSION, research, development, or sales in agricultural engineering. Prefer western states. BS deg in agriculture, major agricultural engineering, 1950, Montana State College. Farm and ranch background. Just completed 21-month tour of duty with Air Force in commissioned status working in maintenance and supply fields. Married. Age 24. No disability. Available now. Salary open. W-260-42

AGRICULTURAL ENGINEER for engineering or sales engineering in irrigation field or public relations work in agriculture, with industry. Any location. BS deg in agricultural engineering, 1950, University of Minnesota. Farm background. Irrigation sales engineering summer 1950. Enlisted service in Army Corps of Engineers, 2 yr, 1950-52, mostly as civil-mechanical engineering research assistant. Engineer assisting in introduction of new products, alloys, and finishes with major producer of aluminum, October, 1952 to July, 1953. Single. Age 27. No disability. Available now. Salary $420-450 per mo, depending on location. W-266-43

NEW BULLETINS

(Continued from page 492)

Comparative Analysis of Hydrographs from Similar Storms on a Watershed Under Timbered and Clear-Cut Conditions, by James L. Smith and George A. Crabb, Jr. Article 35-61 (May, 1953) reprinted from the Quarterly Bulletin of the Michigan Agricultural Experiment Station (East Lansing) May, 1953. Progress report on runoff from a clear-cut area on which hydrologic data for 11 previous years in a wooded condition are available for comparison. Indications of increased runoff are noted.

DOWN TO EARTH ECONOMY – down on the farm

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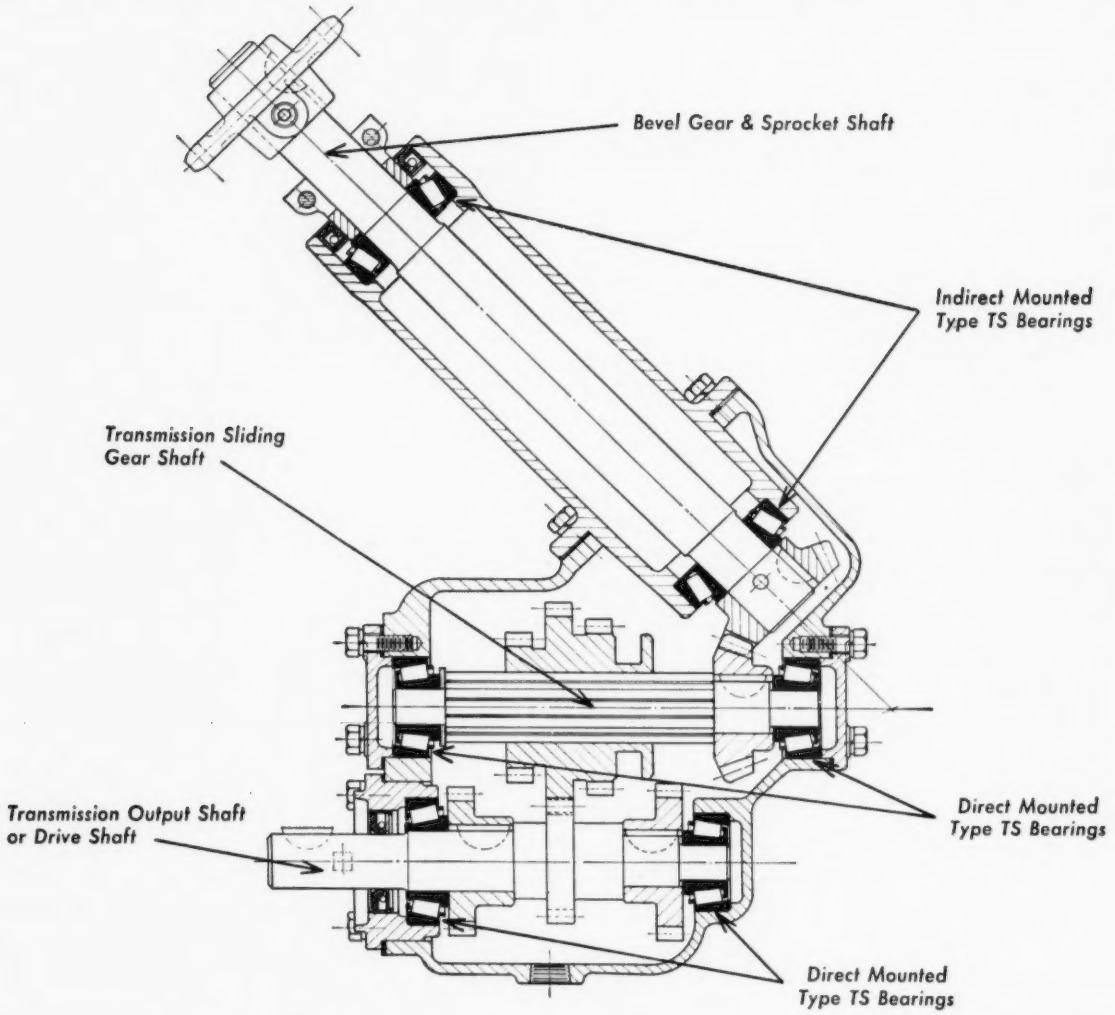
How Allis-Chalmers Designs a High Speed Rake and Tedder Gear Box for Once-a-Season Lubrication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Timken bearings solve three of the biggest design problems facing implement engineers: dirt, combination loads, and ease of operation. They also assure longer implement life, less chance of breakdowns on the job, higher towing speeds.

For information on Timken bearing applications in farm machinery, write today for your free copy of "Tapered Roller Bearing Practice in Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

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